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RESEARCH ON THE TRANSFORMATION OF HISTORIC PATTERNS OF OLD SUMMER RESORTS USING SOCIAL NETWORK ANALYSIS: A CASE STUDY OF KULIANG IN FUZHOU, CHINA

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KEY WORDS: Cultural Landscape; Summer Resort; Social Network Analysis; Face Recognition; Kuliang

ABSTRACT:

Since modern times, Western immigrants have constructed summer resorts in subtropical regions of Asia, resulting in a unique historical occurrence. These summer resorts have loose and flexible distributions that reflect the specific needs and aesthetic preferences of the developers. In the Kuliang summer resort in Fuzhou, China, the seemingly random distribution of buildings and historical landscapes actually conceals complex social relationships between the hosts and managers. This paper discovered that the expansion of housing distribution in Kuliang is closely related to the social network of residents. The research employed various technological methods such as social network analysis and geographic information systems to compute and process complex social relationships and big data. Their analysis has led to three conclusions: (1) The seemingly randomized distribution of buildings and historical landscapes in Kuliang is a result of social relationship development. (2) The formation of Kuliang's summer resort is correlated with the selection of "central members" in the community and has distinct temporal characteristics. (3) Information technology has great potential for the analysis of the formation process of cultural landscapes. These research findings provide important reference for the protection of cultural heritage and understanding the role of social relationships in shaping cultural landscapes.

1. INTRODUCTION

In recent years, modern technological means have provided new solutions for the protection and management of cultural landscapes. These means include GIS databases, laser scanning, aerial photography measurement, GPS handheld devices, and artificial intelligence. As a result, there is now an important opportunity to improve the identification of the dynamic patterns of cultural landscapes.

Summer resorts are a unique phenomenon in the subtropical areas of Asia, and they were mostly developed in modern times by foreign residents. These residents, mainly European and American missionaries or merchants migrated from temperate climate regions and often chose high mountains or islands near cities to build simple rural-style summer houses using local materials. (Li, N. 2011). These summer houses were intended to provide respite from the hot and dangerous summers, particularly for women and children. During other seasons besides summer, local residents took care of the summer buildings, resulting in a "migratory landscape."

Compared to the compact urban concessions or settlements where westerners typically live, the distribution of summer resorts is looser and more flexible, reflecting the specific demands and aesthetic preferences of the developers at that time. Kuliang, a summer resort in Fuzhou, China, built by missionaries in 1886 (Pitcher, 1895), was used as an instrumental case. Located more than 700 meters above sea level, the area boasts a cool climate, which prompted foreign immigrants to build over 120 summer stone cottages here before 1930 (Figure 1). Using historical maps, satellite images, and detailed on-site investigations, the research team identified 20 historical buildings that still exist and collected corresponding property owner information.

Figure 1. Kuliang summer resort, ca.1900 (Source: Ben Robert Marsh's album, author's collection)

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The development of Kuliang has a long history, starting with the arrival of missionaries from three main missions in Fujian: MEM (Methodist Episcopal Church), ABCFM (American Board Church of Foreign Mission), and CMS (Church Mission Society), as well as merchants and consulates. As this research delved further into the history of Kuliang, we discovered that the cottage owners were connected through a hidden social network. For example, missionaries from the same mission tended to live near each other, while merchants preferred to build their homes on the outer edges of the summer resort. Additionally, they tended to lend or sell their cottages to people they were familiar with, who were often from the same mission, country, or organization (Lin, Yang, Ye, and Zhang, 2021).

To gain insight into the historical patterns of Kuliang, which were shaped by this social network, we are using innovative methods such as SNA (Social Network Analysis).

This article aims to address the following key research questions:

1. How can we discover and identify the hidden social relationships among the cottage owners and create a social network map?
2. What is the relationship between the distribution of cottages in Kuliang summer resort and the social networks of the house owners?
3. How does the social network of homeowners affect the development of Kuliang Summer Resort?

2. METHODOLOGY

It is widely accepted that the geographical milieu in which humans are situated and the social networks that they form are mutually constitutive, given that individuals are innately shaped and influenced by this multifaceted environment throughout their developmental trajectories (Fischer, C. S. 1982). This study examines the construction of methodological pathways at both the physical space and social relations levels. (Figure 2)

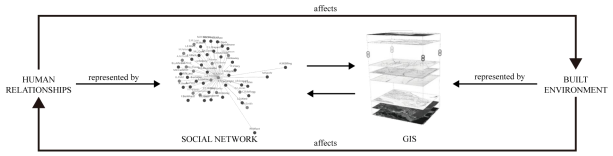

Figure 2. The study of human relationships within the built environment requires communication between SN and GIS structures.

2.1 Constructing a Geographic Information Database for Kuliang

To begin with, understanding the connection between social relations and physical space requires robust geographic information data, which has been supported by empirical research in various interdisciplinary fields, such as SNA (Social Network Analysis) and GIS (Geographic Information System).

We could better model how humans socialize, share information, and form social groups within the complex geographic landscape, if the interpersonal relationships could be analysed in a geographic information system setting (Andris, 2016). Giordano (2022) proposed a GIS-based model designed to study past geography and visualize the spatial and structural features of specific social networks (Giordano et al., 2022). This model was utilized to conduct research on Jewish individuals living in Budapest in 1945. It is evident that constructing geographical databases for analyzing the complex geographical landscape of human socialization, information sharing, and the formation of social groups has become a common and reliable research method. Scholars have already utilized spatial network data to evaluate the geographical characteristics of gang crime hotspots in local competition networks (Radil et al., 2010). Additionally, in the SNA method, the geographic information database constructed through a housing-based modelling approach is the basis for many cities to explore social network relationships. Blondel et al. (2012) constructed a city-level social network using house location data (particularly home addresses) to study individuals' social circles and social differences. (Blondel et al., 2015). These studies have shown that house location data can provide valuable information on the geographic location and social interactions of individuals and groups, supporting research on urban social networks and behavioural patterns. This has also provided a theoretical foundation for the methodological construction of this study.

As mentioned earlier, traditional methods of digitizing geographic information were insufficient to handle the complex terrain of Kuliang. Therefore, the team introduced technologies such as UAV orthophotography and UAV oblique photography and combined them with historical mapping, data organization, and field investigation to develop a preliminary geographic information database for Kuliang.

According to historical records, the residents of the Kuliang summer resort can be classified into several types, including missionaries, merchants, and officials, with the latter mainly from the customs and postal services. For the missionary groups, the research team categorized them based on their missionary work and profession. The houses of the missionaries from the Church Mission Society, the Methodist Episcopal Mission, and the American Board of Commissioners for Foreign Missions displayed a significant clustering pattern. During this stage, the research team marked the houses and their owners on digital images and historical maps to form a database for subsequent analysis and interpretation (Lin, Yang, Ye, and Zhang, 2021).

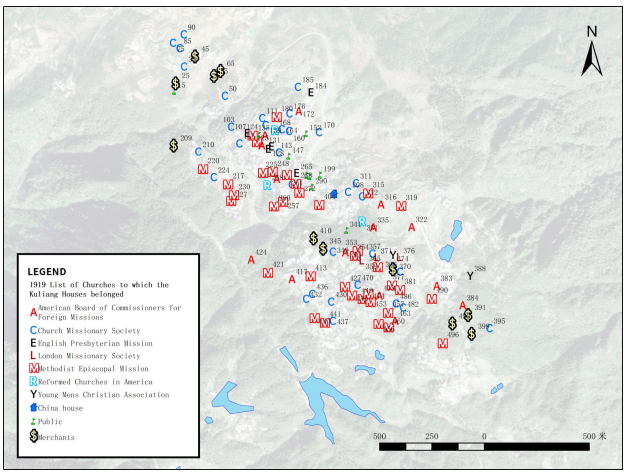

Figure 3. 1919 List of Churches to which the Kuliang Houses belonged

2.2 Constructing the Social Network of Kuliang

Some studies have incorporated social network analysis into their exploration of geographic information databases. For

instance, a similar study conducted in Singapore examined the social networks of the Chinese community following the selection of temple sites (Yan et al., 2020); Grandjean, M demonstrated in his research how to use social network analysis technology to explore the community structure on social media (Grandjean, 2016); Crooks (2015) presented a method to create urban geographic databases using publicly-sourced data and investigated its potential applications in social network analysis (SNA).

Expanding on this idea, we hypothesize that by examining social networks, we can gain insight into how human relationships impact housing distribution and selection. As a result, we aim to construct a social network of Kuliang. To accomplish this, we will:

1. Thoroughly investigate the personal histories of all housing owners, including information on their families, nationalities, religions, and occupations.
2. Analyze historical photographs to identify interpersonal relationships.
3. Utilize coding techniques to calculate and ultimately construct a relationship matrix.

2.3 Drawing a Social Network Map of Kuliang

Afterwards, the team used above information to construct a social network map, assigning weights to interpersonal relationships based on factors such as blood ties and kinship, and quantifying them.

To do this, the team relied on two sources of information: genealogy and social relationships of Kuliang homeowners (as shown in Figure 2-2), as well as the frequency of group photos taken of the 2,406 homeowners and residents. By using the frequency of these photos as evidence to weigh the strength of interpersonal relationships, the team was able to accurately represent the social network of Kuliang. The process of partitioning the population is briefly mentioned, and Table 1 provides further details.

After completing the above preparations, the research team would compare the generated social network with the distribution of houses to confirm whether there was a correlation between the social network and housing distribution in Kuliang.

3. RECONSTRUCTING THE SOCIAL NETWORK OF KULIANG

3.1 Data Acquisition

The raw data of this study were obtained from the “Kuliang Sketch” made by Rev. P. W. Pitcher in 1895 and 1907, and also “Kuliang Handbook” published by Kuliang Council in 1919, 1933 and 1934, which contains the name list of the cottage owners. The 1933 and 1934 data included the names of the tenants for that year as well. The research team verified each piece of personal name, mainly based on public data from foreigner and missionary archives in China (Huang, 2017), the Annals of Christian Travel in China; passport application records from the U.S. Embassy in China between 1850 and 1949, steamship company's passengers lists, and publicly available data from genealogy sites, such as Ancestry.com and Familyresearch.org (Figures 4).

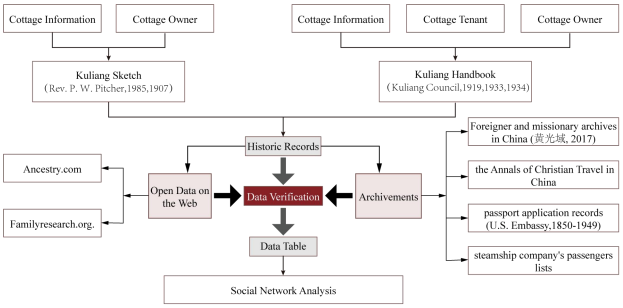

Figure 4. Experimental Data Process Diagram.

3.2 Social Network Construction

Kuliang, being one of the earliest and largest foreign residential summer resorts in modern China, had a unique and diverse population. The early foreign residents in Kuliang can be categorized into four groups, namely missionaries, merchants, political figures such as consuls, and other officials such as customs and shipyard staff. As communication became more frequent, Chinese people related to foreign residents gradually moved up to the hills to reside. In the 1930s, national capitalists also started residing in Kuliang. The diverse background of Kuliang residents has contributed to their complex and diverse social relationship networks and cultural environment.

To efficiently manage and utilize the vast amount of information about historical figures in Kuliang, the research team developed a unique genealogy platform named "Family Tree." Each person was assigned a single entry, containing information such as birth and death dates, place of birth, education, organizational affiliations, and social interactions. The platform employed artificial intelligence to automatically calculate the social relationships between every two nodes in the graph, taking into account factors such as kinship, in-law relationships, clan relationships, and hierarchical relationships. This allowed the team to determine the proximity of individuals in the social network based on the weight assigned to their relationships (Figure 5). By utilizing this platform, the team was able to create a comprehensive database containing biographical information, contributions to Kuliang's development, and impact on cultural exchange between Chinese and foreign residents, which can be accessed by the public and scholars alike.

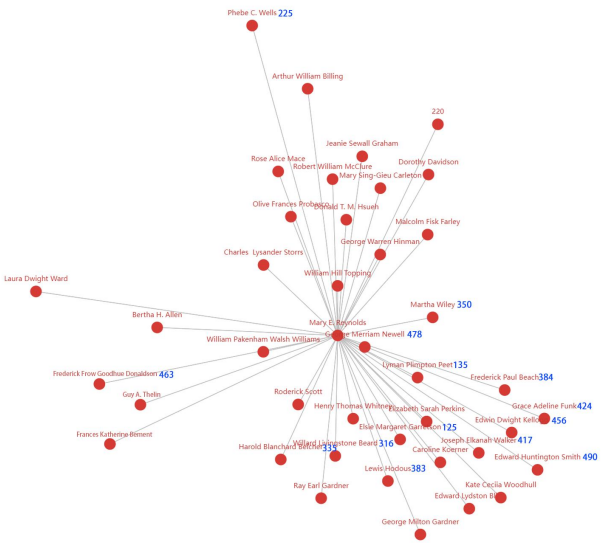

Figure 5. Mary E. Reynolds’ social network, generated by the “Family Tree” platform. Mary was a Methodist missionary in China. G. M. Newell, her husband, was an important educational missionary and lived in Fuzhou for 37 years. (Source: Family Tree platform).

3.3 Supplementing with Facial Recognition Technology

In addition to the traditional social relationships discussed earlier, we also explored the use of group photos as an additional source of relational data. During the late 19th century, when the summer resort was at its peak, photography had just become popular, and group photos at the time were a strong indication of close relationships between the subjects. The research team obtained well-preserved missionary archives and photo albums from prestigious academic institutions such as Yale University and Harvard University, as well as databases like the United Methodist Church and the Church Mission Society Database.

The "family tree" platform employed facial recognition technology to identify individuals in group photos, linking their image data in a series and reconstructing a social network. This approach enabled the supplementing of social relationships between individuals who appear in the same photo and potentially revealing interpersonal relationships that may not have been documented or verbally recorded. Figure 6 and Figure 7 provide visual examples of this method.

Figure 6. Celebration 75 birthday and 50 year missionary service of Emily S. Hartwell, April 16, 1934. 58 persons were identified by the AI from this photo, generating a big social network (Source: Yale University Divinity School, YDS/RG008/094/0001/0009).

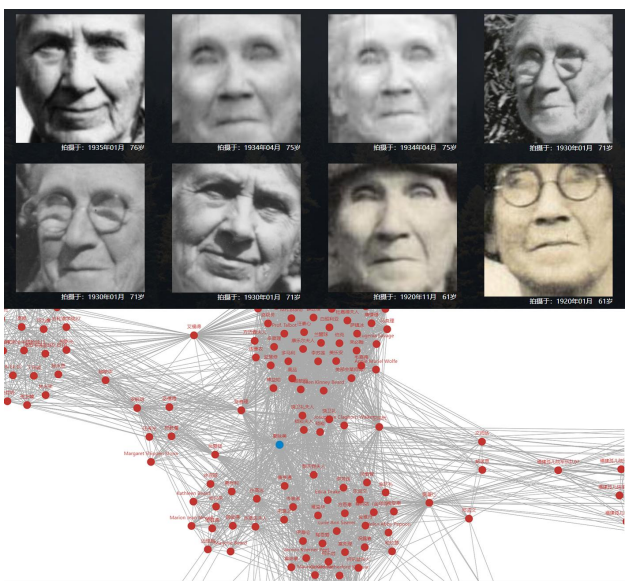

Figure 7. Emily S. Hartwell’s faces data, and her social network, generated from 17 different group photos. (Source: “Family Tree” Platform)

Using the structured data and supplementary group photo relationships discussed earlier, we created a social network by representing each individual or organization as a node and each connection between them as an edge. We utilized online database systems and visualization tools to establish a data linkage mechanism that enables automatic updating of the social network model. To quantify social relationships between individuals, we assigned them into four levels: direct kinship, extended family, close companionship, and casual social interactions, each with specific weights and associations (Table 1).

Relationship	Basic Weight	Specific Connection
Direct Kinship	5	Parent-child relationship within one generation (including adoption)
Extended Family	4	Collateral kinship relationship, including by marriage
Close Companionship	3	Employer-employee, superior-subordinate, colleague, co-worker, fellow churchgoer, classmate, etc.
Casual Social Interactions	2	Group photo, acquaintance

Table 1. Weighted Values of Social Relationships

Based on the weighted values in the table, we conducted a logical query of this structured data stored in a relational database. The formatted data was then visualized using an ECharts with a force-directed layout, utilizing both mutual repulsion and a custom quantified social relationship force. After a sufficient number of iterations, the force-directed layout produced a relational graph, clustering related nodes into one or more cohesive groups, providing an intuitive display of social relationships between different groups. Additionally, the use of group photo relationships as a supplementary aid to the relationship graph provided a more comprehensive representation of the information, as compared to traditional social relationship graphs. (Figure 8, Figure 9).

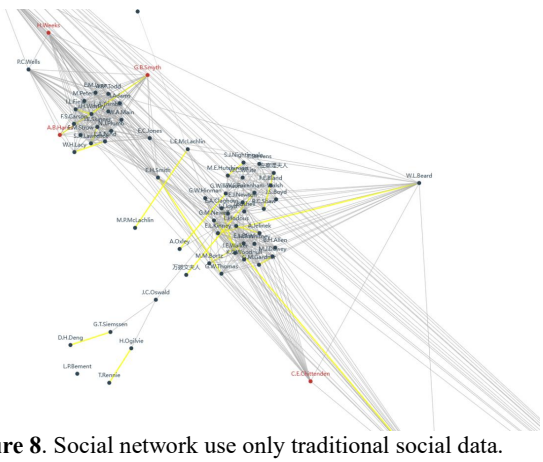

Figure 8. Social network use only traditional social data.

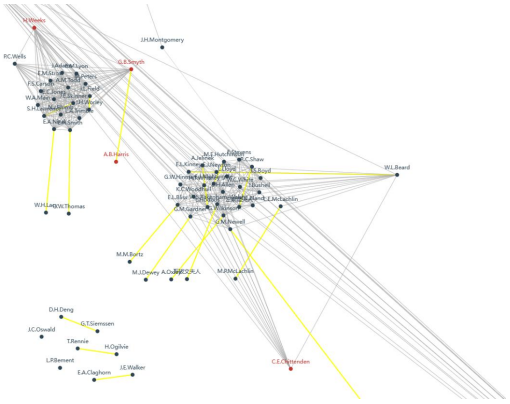

Figure 9. Social network added group photo social relationships automatically extracted by facial recognition technology.

As can be clearly seen in the figure above, the left image containing only traditional social data has many isolated points in the social relationship graph due to lack of detailed social knowledge (e. g. T. Rennie, L. P. Bement, etc.) (Figure 8). However, after adding group photo social relationships automatically extracted by facial recognition technology, the number of isolated points in the entire relationship graph is significantly reduced and a clear cluster emerges from the original relationship graph (Figure 9). The three clusters in the figure highly overlap with the actual historical social relationships in Kuliang. It can be seen that group photo relationships can complement the construction of social networks and help us to discover potential social relationships from cross-modal data.

4. SOCIAL NETWORK OF KULIANG AND ITS IMPACT ON THE SUMMER RESORT

4.1 The Evolution of Housing Distribution in Kuliang

During the history of Kuliang, the ownership of summer cottages underwent significant changes. Between 1886 and 1895, 16 out of the 40 cottage owners were merchants, while the other 24 were politicians and missionaries（Pitcher 1895）. This represented the social network during the Treaty Port era in Fuzhou, which was characterized by tea trading, Christian faith, Imperial Customs, Post, and consulates.

With the decline of Fuzhou's tea trade, missionaries gradually replaced merchants as the majority of Kuliang residents. Most of the Protestant missionaries were from the United Kingdom and the United States, and they served the three major churches in Fuzhou—the Church Mission Society (CMS), the Methodist Episcopal Mission (MEM), and the American Board of Commissioners for Foreign Missions (ABCFM). In addition, the group of missionaries also includes the English Presbyterian Mission (EPM), the Reformed Church in America (RCA), and Catholic Dominican churches. In 1919, there were as many as 120 cottages for foreigners in Kuliang, 80% of which belonged to the missionaries (Figure 10).

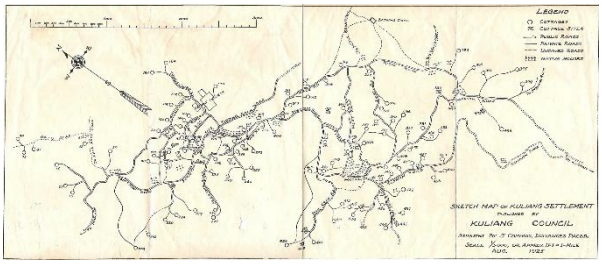

Figure 10. Sketch map of Kuliang settlement, published by Kuliang Council in 1925.8, showing the distribution of the cottages (Source: Yale University Divinity School)

After the anti-Christian movement in 1920s, a large number of missionaries left China. Kuliang is gradually favoured by some wealthy Chinese, including the Fuzhou's modern national capitalists, such as the Liu family of the Foochow Electrical & Co. However, through the analysis of social networks, we can still see the hidden "inheritance" relationship behind the change of these properties. Some Chinese Christian leaders, who had close ties to the foreign missionaries, such as Donald Hsueh, owned the cottages of their foreign co-workers (Figure 11).

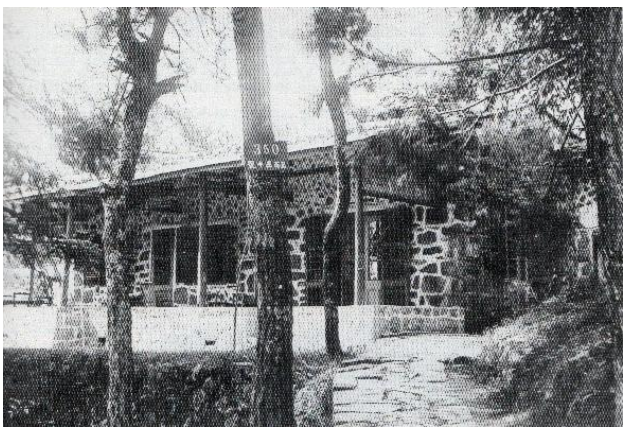

Figure 11. Donald Hsueh’s cottage (No.350) in Kuliang, was formerly belonged to Martha Wiley, a Congregational missionary, who “adopted” Donald when he’s a kid. Martha still lived here with Donald and his wife Katherine during the summer season, after Donald “owned” the cottage. (Source: Letters from the Dragon's Head: Martha Wiley's China 1900-1947).

With the development of society, the residents of Kuliang have gone through the evolution from businessmen to missionaries and then to the wealthy. Each historical period in Kuliang has given rise to different "central figures" or "pioneers" in the complex social network due to the complexity of social relationships. These individuals, with their unique social status and influence, played indispensable roles in the economic and social development of the Kuliang region during their respective eras. To better understand the formation of social networks and their impact on the economy, it is necessary to identify and integrate these individuals as "key nodes" into the social network analysis. Through analyzing these nodes, we can gain deeper insights into the evolution of Kuliang 's society and the impact of "central figures" on the distribution of housing in Kuliang.

4.2 Identifying Central Figures in Kuliang

The research team found that there were clear social groups and patterns in the Kuliang Summer Resort community in history. The team used digital maps to show the road systems and

cottage distribution in different periods, and analyzed the accessibility of cottages through the GIS. Those cottages built earlier, centrally located, and more public were identified, forming a building distribution map. At the same time, the research team used the "Family Tree" platform to calculate and capture the cottage owners with high centrality in different social networks (Table 2). The results have shown that most of these people were the core figures in the social groups they belonged to in history, and they had multiple social identities. For example, G. M. Newell and L. P. Peet were not only missionaries of ABCFM, but also directors of Fukien Christian University. W. L. Beard had important positions in Fukien Christian University and YMCA, and was also the Chairman of Kuliang Council. These people were the central nodes of the Kuliang social network (Figure 12).

Cottage Owner Name	Degree	NrmDegree	Share
George Merriam Newell	100	4.735	0.041
Mary E. Reynolds	93	4.403	0.039
Lyman Plimpton Peet	85	4.025	0.035
Olive Frances Probasco	75	3.551	0.031
Phebe C. Wells	69	3.267	0.029
Martha Wiley	62	2.936	0.026
George Warren Hinman	60	2.841	0.025
Arthur William Billing	58	2.746	0.024
Willard Livingstone Beard	57	2.699	0.024
Henry Thomas Whitney	48	2.273	0.02
William Pakenham Walsh Williams	46	2.178	0.019

Table 2. Analysis of the Social Network Centrality of Kuliang cottages owners.

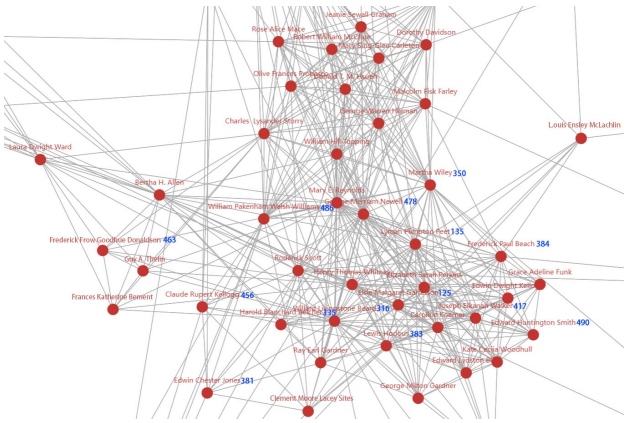

Figure 12. Social Network of Kuliang cottage owners, showing the centrality of Kuliang cottages owners. (The number of edges for each node is proportional to its centrality, and the blue number on the node represents its corresponding house number.)

Based on the cognition of social relations, the team further established a connection between social identity and landscape structure. The study found that the building distribution map and the social relationship network map have similar patterns: Around the houses of the "pioneers" and "community leaders", their relatives and co-workers gradually rent land to build cottages, and they had relatively close node distances in the social network. A little further away were the tenants of the house, whose place of residence was not fixed, but tends to rent the house of "acquaintances" from the same organization. The cottage patterns also demonstrated that groups from churches and businessmen had clear social boundaries at that time.

Utilizing the vast social network we have developed, the research team conducted further research on the relationship between social identity and landscape structure to address two questions: Is there a correlation between the distribution of houses in Kuliang and the social relationships between their owners? What is the nature of the relationship between a house's owner and their neighbours? As such, this research was conducted in two parts:
(1) Analysis of house distribution
(2) Analysis of the relationship between house owners and their neighbours

4.3 Analysis of House Distribution

Given that early site selection was influenced by modern treaties, the initial settlement locations of Kuliang 's first settlers displayed a certain degree of randomness. To analyse house distribution, we used a GIS system to plot the distribution of houses between 1895 and 1907. Through this, we found that the pattern of building distribution was similar to that of the social network map. After conducting multiple tests, this research decided to compare and analyze the incremental changes between the two time periods in order to improve the accuracy of the research results.

Using GIS, we plotted the distribution of houses between 1895 and 1907 (Figure 13), with red representing houses in 1895 and black representing houses added between 1895 and 1907. Using Python, we plotted a social network image for the same time period (Figure 14), assigning weights based on the closeness of relationships and connecting house owners with each other. Red lines represent the first settlers (those who settled before 1895) and blue lines represent the second wave of settlers (those who settled between 1895 and 1907 in Kuliang).

This research revealed that the patterns of building distribution and social networking were similar. House tenants who were relatives or colleagues of the "pioneers" and "community leaders" gradually rented land to build small houses around their houses and had relatively close nodal distances in the social network. Further away were tenants with lower kinship or social ties whose housing location was not fixed, but tended to rent from acquaintances in the same organization. The village pattern also showed that groups from the church and merchants had clear social boundaries at the time. Additionally, we found that the social networking pattern formed by tenants living further away from the pioneers and community leaders was relatively more dispersed.

This indicates that the social networks of early settlers played a significant role in the formation of housing distributions, as these early settlers mostly possessed notable social influence and associated resources. These advantages were reflected not only in site selection decisions but also in the critical role played by the social network in the development of the small village. Through such social networks, these "pioneers" and "community leaders" could not only gather more resources and information but also exert better control over the local political and economic life. Meanwhile, other residents followed in the

footsteps of these pioneers, building network relationships similar to those of the pioneers, mutually dependent, and forming a dynamic community.

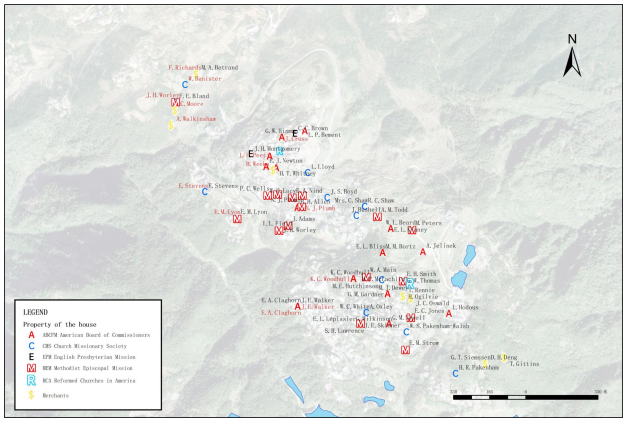

Figure 13. House distribution between 1895 and 1907 in Kuliang.

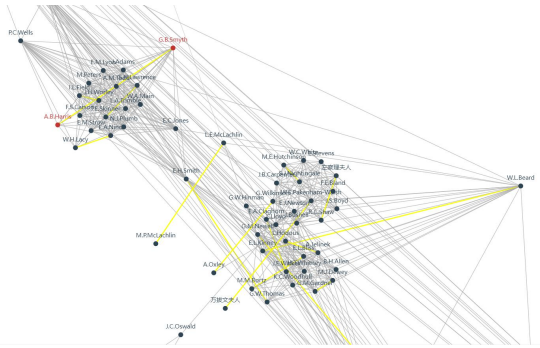

Figure 14. Social network between 1895 and 1907 in Kuliang.

4.4 Analysis of the Relationship Between House Owners and Their Neighbors

The distribution of houses and social relationships between homeowners are two crucial factors in social network analysis research. In this study, we selected some homeowners with high centrality in the Kuliang social network as research objects. By pulling their social networks and using GIS technology, we mapped the corresponding house distribution for this social network and analyzed the relationships between homeowners and neighbors. Through analyzing this data, we found that many neighbors came from the social networks of these homeowners, which seems to indicate a significant influence of social networks on the formation of neighbor relationships.

Based on the findings above, we further analyzed the case of G.M. Newell (Figure 15). In this case, many new neighbors appeared in G.M. Newell's social network between 1895 and 1907, and many of these neighbors eventually became close associates of G.M. Newell. We also found that many of these new neighbors were already known individuals within the social network. For example, E.C. Jones, L. Hodous, E.T. Thomas, J. Hind, C.R. Kellogg, and others.

This suggests that the structure of social networks has a certain influence on the distribution of houses and the formation of neighbor relationships. Social network structure can facilitate or strengthen the formation of neighbor relationships, as people who have closer relationships in social networks often have similar backgrounds, belong to the same church organization, or have similar work colleagues. At the same time, neighbor relationships can also impact the formation and development of social networks, as contacts between neighbors can encourage more people to join the social network and expand the scope of social connections.

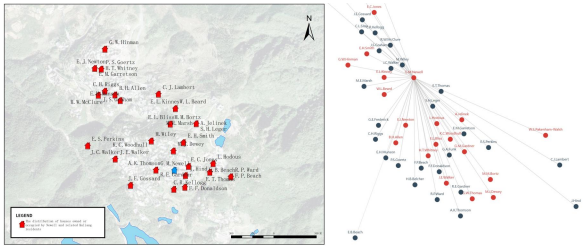

Figure 15. Comparison between house distribution and social network of G.M. Newell

5. CONCLUSION AND DISCUSSION

This study applies digital technologies such as geographic information systems and social network analysis, and integrates building distribution, historical attributes, and social relationships to conduct an in-depth research on the historical landscape pattern of Kuliang Villa area. The conclusions of the study include:

(1) The seemingly random distribution of buildings and historical landscapes in the Kuliang Villa area is the result of the development of social relationships. The features of "grouping" are clearly reflected in the local landscape. The nationality, affiliation, and social network of property owners are factors that promote the formation of the landscape, among which the influence of ownership and kinship is the most prominent.

(2) The formation of the Kuliang Villa area is closely related to the selection of "central members" in the community, but has obvious temporal characteristics. In the early stages of community formation, the land available for rent in Kuliang was limited, resulting in a certain degree of randomness in housing distribution. As the community developed, the gravitational force of "central members" affected other members of their social network, resulting in the phenomenon of "living next to acquaintances". In the late 1920s, with the weakening of the Church's power and the trend towards Chinese national autonomy, the social network of Kuliang underwent another transformation, and the correlation between social networks and building distribution gradually weakened.

(3) The study employs geographic information technology to reconstruct Kuliang's historical landscapes; social network analysis methods to generate Kuliang's social networks; and facial recognition technology to excavate hidden interpersonal relationships. By integrating the above research, AI presents the potential application of information technology in the analysis of the formation process of cultural landscapes, in the face of complex social networks and massive data.

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