Research on the Visualization Design of Pagodas in Liaoning Province, China

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Abstract. As the central region of ancient culture in northern China, Liaoning province possesses numerous remarkable pagodas. These pagodas in Liaoning province integrate Central Plains culture, Nomadic Culture, and Western Region culture, giving rise to distinctive architectural styles, aesthetic cultural trends, and religious beliefs, while showcasing exquisite ancient construction techniques. Among them, the Liao pagodas stand out, with over 80 large-scale Liao pagodas nationwide, of which Liaoning province alone boasts around 40, accounting for half of the country's total. This paper, from the perspective of digital humanities, conducts an analysis and research on the data of pagodas in Liaoning province through visualization design, aiming to further explore the development process and humanistic value of these pagodas.

Keywords: pagodas, ancient architecture, visualization

1 Overview of Pagodas in Liaoning Province

The origin of pagodas can be traced back to the Sanskrit word "Stupa" from India, which is a borrowed term from Buddhism.[1] Stupa initially referred to architectural structures used to enshrine the Buddha and his relics. After its introduction to China, the Stupa gradually assimilated Chinese architectural characteristics and aesthetic features from various dynasties and regions, evolving into the distinctive Eastern-style pagodas, pagodas, we see today.

As the central region for ancient cultures in northern China, Liaoning has formed a unique cultural sphere where the Han culture from the Central Plains and the diverse cultures of northern ethnic minorities merge and interact due to its special geographical location and historical origins. Pagodas in Liaoning are one of the carriers of ancient northern Chinese culture. In the history of ancient Chinese architecture, the architectural art of Liaoning's pagodas, particularly the Liao-style pagodas, is unparalleled. The extensive use of large-scale sculptural symbols on the main body of the buildings is a feature not found in any other dynasty or region in Chinese architecture. During subsequent periods such as the Jin, Yuan, Ming, and Qing dynasties, the pagodas in Liaoning thrived alongside the development of Buddhism. Over the centuries, the pagodas in Liaoning have developed their own unique paths of dissemination and integration, constantly assimilating the artistic and cultural characteristics of their respective dynasties and regions, making significant contributions to architectural art, aesthetic form, sculptural art, and painting art. They possess high cultural and artistic value and have influenced related fields such as religious studies, history, architecture, and sociology.

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2 Visualization Design Strategies of Pagodas in Liaoning Province

Given the vast number of pagodas in Liaoning, it is necessary to determine the scope of data collection and the types of data to be collected before visualization design. The collected data needs to be classified and organized. Subsequently, the extracted organizational information should be compared horizon-tally and vertically to facilitate multidimensional cross-analysis. Finally, the analyzed and filtered data should be visualized, constructing new hierarchical relationships based on logical coherence, enabling viewers to quickly and accurately understand the design intent and data relationships, thus achieving multidimensional interpretation and presentation of information.

The primary sources of data for pagodas in Liaoning are specialized books on pagodas. These books provide rigorous, comprehensive, and accurate coverage of the situation of pagodas in Liaoning. Some notable works include " Grand View of Pagodas in China,"[2] "Collection of Pagodas in China,"[3] " Liaoning Ancient Pagoda Annals,"[4] and "Tracing Pagodas in Western Liaoning." [5] It's worth noting that for the Shuangtagou Pagoda and the Yin Pagoda in Anshan, their construction dates are unknown, but they are speculated to have been built during the Liao and Jin dynasties based on their architectural styles. Therefore, when collecting and processing data, these two pagodas are categorized under the "Liao-Jin period".

The data on pagodas mainly covers four aspects: numerical data, categorical data, textual data, and geographical data.[6] From a perceptual perspective, this data can be divided into explicit information and implicit information. Explicit information refers to the physical information that can be perceived through the senses, such as the height and classification of pagodas. This data can often be quantitatively categorized and analyzed. Implicit information refers to the humanistic and historical information that cannot be directly perceived through the senses. Implicit information often involves multidimensional and cross-referenced information, requiring the exploration of the inherent connections among various types of data and their logical organization for presentation.[7] For example, the historical development of pagodas in Liaoning and the changes in decorative patterns of pagodas in different dynasties."

As an ancient cultural heritage that has endured for thousands of years, pagodas are a subject of research closely intertwined with history, society, regional humanities, and more.[8] The related information and data are often complex and diverse. From the physical attributes of the pagodas to their cultural backgrounds, these information and data involve multiple dimensions. Therefore, when under-taking visual representation, it is important to consider the readability, logical coherence, and artistic aspects of the design.[9]

3 Presentation Forms for Visualization Design of Pagodas in Liaoning province

3.1 Distribution of Pagodas in Liaoning province

In Liaoning province, there are a total of 69 pagodas. Using a bubble map format to display their distribution based on prefecture-level cities, different colored bubbles represent different cities, and the size of the bubbles represents the number of pagodas in each city, with larger bubbles indicating a higher quantity. The visualization of the distribution map clearly shows

that the top three cities with the highest number of pagodas in Liaoning province are Chaoyang, Jinzhou, and Anshan. Among them, Chaoyang has 15 pagodas, which is the highest number.

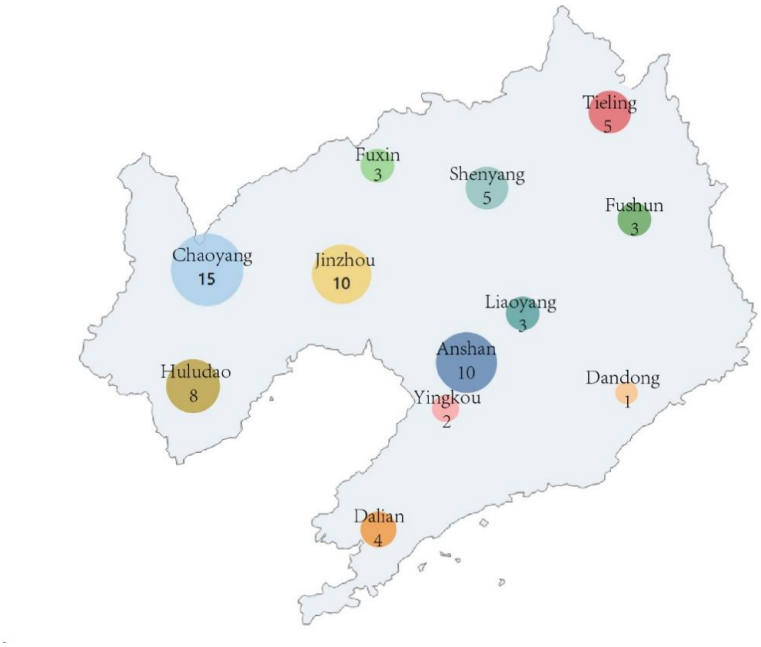

Fig. 1. Distribution of Pagodas in Liaoning province

During the Liao Dynasty, despite the vast territory, the economic and cultural activities were concentrated in the "Five Capitals" of the Liao Dynasty and the surrounding region of the Xiliao River. In these developed areas, centers for the spread of Buddhist culture gradually formed. At that time, there were a total of seven Buddhist centers in the Liao Kingdom, namely: Linhuangfu in Shangjing, Liaoyangfu in Dongjing, Xijin in Nanjing, Dadingfu in Zhongjing, Datongfu in Xijing, Xingzhongfu, and Juehua Island. In the present-day Liaoning province, three Buddhist centers of the Liao Dynasty are located: Liaoyangfu in Dongjing (present-day Liaoyang), Xingzhongfu (present-day Chaoyang), and Juehua Island (present-day Xingcheng, Liaoning province). According to the bubble map, it can also be observed that most of the Buddhist pagodas in Liaoning province are built around these Buddhist center cities and their surroundings, which aligns with the pattern of constructing large-scale Buddhist pagodas near the Liao Dynasty's Buddhist centers. The remaining scattered pagodas are found in other cities without a clear pattern, suggesting that these cities did not develop into significant Buddhist centers during other historical periods.

3.2 Relationship between Height of Pagodas in Different Dynasties and Building Materials

When collecting data on different dynasties, the Anshan Silver Pagoda and the Huludao Shuangtagou Pagoda cannot be definitively attributed to a specific construction dynasty. However, based on their characteristics, scholars have classified them under the Liao and Jin

dynasties. The number of pagodas categorized by dynasty is as follows: 40 pagodas from the Liao dynasty, 2 pagodas from the Liao-Jin period, 7 pagodas from the Jin dynasty, 1 pagoda from the Yuan dynasty, 9 pagodas from the Ming dynasty, 9 pagodas from the Qing dynasty, and 1 pagoda from the Republic of China.

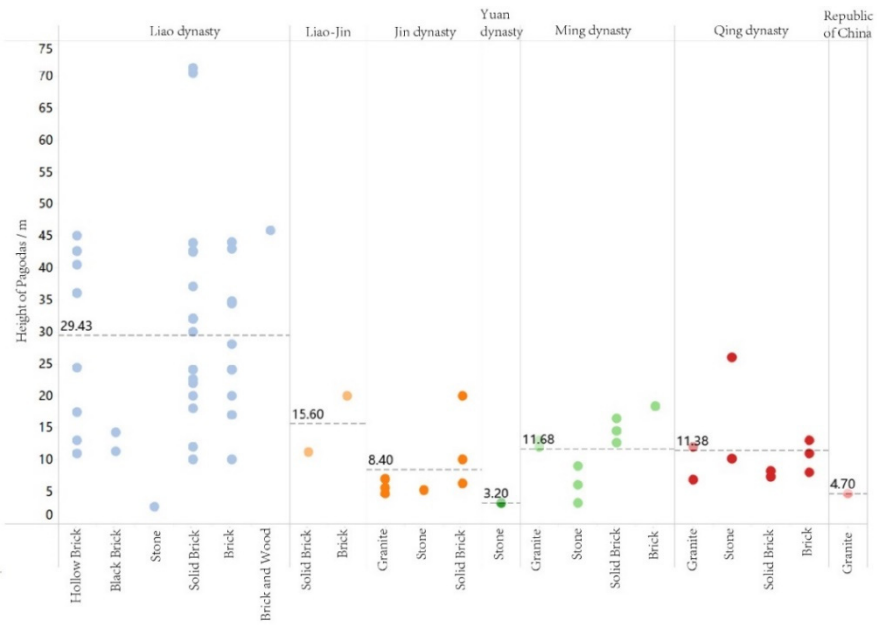

Fig. 2. Relationship between Height of Pagodas in Different Dynasties and Building Materials

Both the dynasty and building materials are categorical data, while the pagoda height is numerical data. For the visualization, a scatter plot can be used, with the x-axis representing different building material categories, the upper x-axis representing the corresponding dynasties, and the y-axis representing the numerical pagoda height. Each data point represents an individual pagoda, with different colors indicating different dynasties, making it visually clear and easy to distinguish. When hovering over a data point in Tableau, the pagoda name and specific numerical values can be displayed. This design allows for a clear view of the maximum and minimum pagoda heights within different material categories, as well as the trends and aggregations of the data. Additionally, the visualization can include the average pagoda heights for each dynasty, represented by gray horizontal lines.

Through the visualization, it can be observed that the tallest pagodas in Liaoning province are solid brick pagodas, while the shortest are stone pagodas. Solid brick pagodas are the most numerous, with a concentration of pagoda heights around 10 meters. Hollow brick pagodas and brick pagodas have similar maximum and minimum values. Stone pagodas and granite pagodas have generally lower heights. There are only two black brick pagodas with similar heights, around 13 meters. The existing pagodas in Liaoning province are mainly brick and stone pagodas, with no purely wooden structures, except for one brick and wooden pagoda. This is mainly due to the cold and dry climate in Liaoning province, where wooden structures are prone to wear and collapse in such an environment. Brick and stone structures, on the

other hand, have greater load-bearing capacity, fire resistance, and resistance to corrosion, making them more durable over time. In addition to environmental factors, advanced brick-making techniques have also contributed to the prosperity of brick pagodas in Liaoning province. According to the "Construction Method," the Northern Song Dynasty had highly efficient brick production, and the Liao Dynasty adopted similar techniques. As a result, the construction of brick pagodas in the Liao Dynasty reached an unprecedented scale.

Furthermore, the tallest pagoda in Liaoning province is 71.25 meters (Guangji Temple Pagoda from the Liao dynasty), while the shortest pagoda is 2.6 meters (Huai Shu Dong Pagoda from the Liao dynasty). Among the seven dynasties, the Liao dynasty has the highest average pagoda height, at 29.43 meters. This aligns with the characteristic of large and grand pagodas in the Liao dynasty. From a cultural perspective, due to the strong emphasis on Buddhism during the Liao dynasty, the construction of Buddhist pagodas served to promote and worship Buddhism. The tall and magnificent pagodas in Liaoning province during the Liao dynasty perfectly showcased the devotion to Buddhism and its teachings. In terms of architectural technology, besides the advancement in brick-making techniques during the Liao dynasty, the prosperous development of construction techniques can also be seen from the majestic size of Liao dynasty pagodas. The average pagoda heights during the later periods of the Liao-Jin, Jin, Ming, and Qing dynasties do not differ significantly, with a maximum difference of only 7.2 meters. Although the Jin dynasty mainly continued the architectural style of the Liao dynasty, often collectively referred to as "Liao-style" in architectural history, the average height of Jin dynasty pagodas in Liaoning province is only about one-third of the Liao dynasty pagodas. This may be due to the fact that the economic, political, and religious centers in the later dynasties were not in Liaoning province, and there was not as much investment in the construction of tall Buddhist pagodas as during the Liao dynasty. Therefore, the pagodas built during these periods were generally shorter in height and fewer in number. As there is only one pagoda each from the Yuan dynasty and the Republic of China in Liaoning province, no general conclusion on the relationship between pagoda height and dynasty can be drawn. Analyzing the relationship between building materials and dynasties, it can be observed that granite pagodas only appeared in Liaoning province starting from the Jin dynasty, and they continue to exist in the Ming, Qing, and Republic of China periods. This may be related to the development of granite extraction and usage techniques during the Jin dynasty. Hollow brick pagodas, black brick pagodas, and brick and wooden pagodas are unique to the Liao dynasty in Liaoning province

3.3 The relationship between the number of pagodas, cities, and building materials

Cities and building materials are categorical data, while the number of pagodas is numerical data. To better display the distribution of pagodas with different materials in each city, a heatmap can be used for visualization. The x-axis represents the various cities in Liaoning province, the y-axis represents the different building materials, and the grid formed by the intersection of the x and y axes represents the number of pagodas, with darker colors indicating a higher quantity. A suitable color for the heatmap can be the earthy yellow that matches the color perception of bricks and stones.

Through the visualization, it can be observed that solid brick pagodas have the widest distribution, with only Dandong city not having any solid brick pagodas. Jinzhou city has the highest number of solid brick pagodas, with a total of 6 pagodas. Chaoyang city has the

highest number of hollow brick pagodas, also with a total of 6 pagodas. There's only 1 pagoda built with brick and wood, which is the Chongshou Temple Pagoda in Tieling city. Stone pagodas are relatively evenly distributed, with over half of the cities having 1 stone pagoda. From the heatmap, it can be seen that there are a total of 8 hollow brick pagodas in Liaoning province, with 6 of them concentrated in Chaoyang city, and the remaining 1 each in Fuxin city and Huludao city. By hovering over the grid in Tableau, the pagoda name and information can be displayed. These 8 hollow brick pagodas are all Buddhist pagodas from the Liao dynasty. Combining this with a bubble map, it can be observed that Chaoyang city, Fuxin city, and Huludao city are all located in the western part of Liaoning province and are not far from each other.

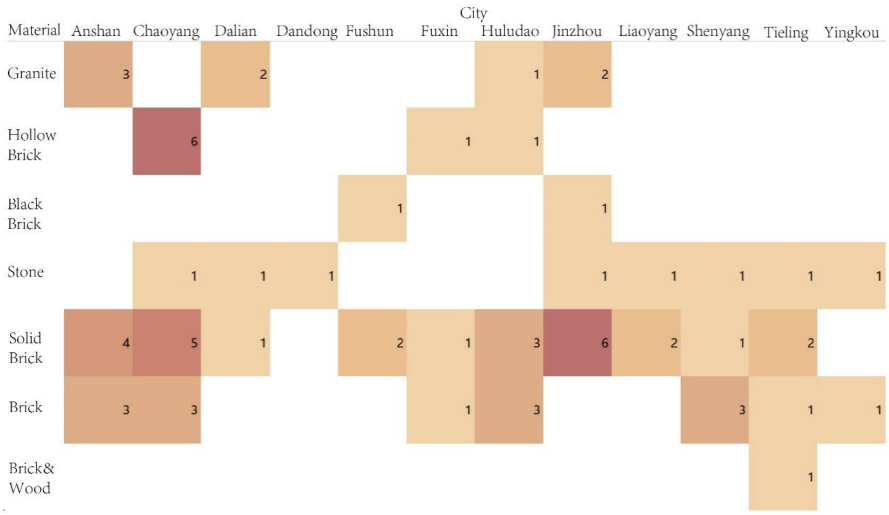

Fig. 3. The relationship between the number of pagodas, cities, and building materials

Therefore, it is speculated that during the Liao dynasty, there might have been large-scale brick kilns dedicated to producing hollow bricks near Chaoyang city. Similarly, except for Dandong city, it is possible that the other 11 cities had brick kilns for producing solid bricks, with Anshan city, Chaoyang city, and Jinzhou city, which have the highest number of solid brick pagodas, potentially being the central distribution points. Granite pagodas are only found in Anshan city, Dalian city, Huludao city, and Jinzhou city, which are all located in the southern part of Liaoning province, surrounding the Bohai Bay. Due to the inconvenience of transporting granite in ancient times, the optimal decision for construction was to use locally available materials, and it is speculated that these four cities in Liaoning province have granite pagodas due to their geological characteristics.

3.4 The relationship between decorative categories and pagodas

In the pagodas of Liaoning province, there are a total of 87 different types of decorations. They can be roughly categorized into Buddhist deities, artifacts, animals, plants, patterns, architectural decorations, and text. When collecting the data, the names of the decorations on each pagoda were recorded (if the same type of decoration appears multiple times on a single pagoda, it is only recorded once, without noting the total count of that decoration on the

pagoda). Subsequently, all the pagoda's decoration data was classified, and the number of pagodas possessing each decoration was compiled. This number can also be seen as the frequency of occurrence of that decoration in the pagodas of Liaoning province.

The Yuan Dynasty and the Republic of China each have only one pagoda (the Kublai Pagoda and the Zhenrenguan Stone Pagoda, respectively). The Kublai Pagoda only has the "text" decoration, while the Zhenrenguan Stone Pagoda has no decorations. Due to the limited number of pagodas and the small amount of decoration data for these two dynasties, this section does not include these two pagodas.

3.4.1 The relationship between the number of pagodas and the types of decorations they contain

Decorations belong to categorical data, while the number of pagodas is numerical data. To illustrate the number of pagodas with different decorations in Liaoning province, we can use a bubble chart where the size of the bubbles rep-resents the number of pagodas, and the color intensity indicates the magnitude of the values. Approximately 13 main types of decorations dominate the scene. "Buddha niche" is the most common decoration, found in 40 pagodas in Liaoning province. The decorations "Flying deity" and "Buddha statue" are tied for the second most frequently occurring decorations. The remaining main decorations primarily consist of Buddhist deities and precious objects.

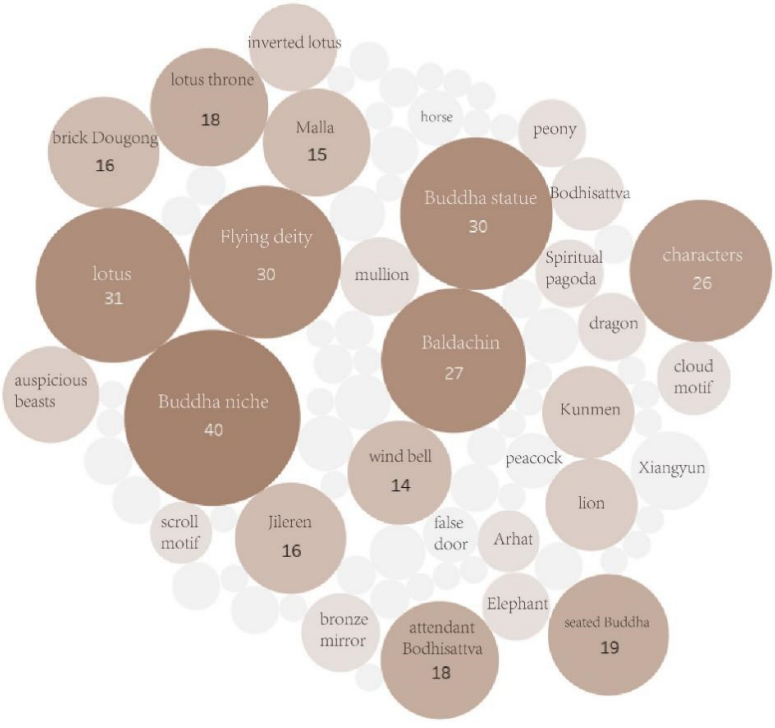

Fig. 4. The relationship between the number of pagodas and the types of decorations they contain

3.4.2 Average Number of Decoration Types per Pagoda for Each Dynasty

Organize the data by dynasty and further analyze the average number of dec-oration types per pagoda for each dynasty. A treemap can visually represent the data size and patterns across different dynasties.

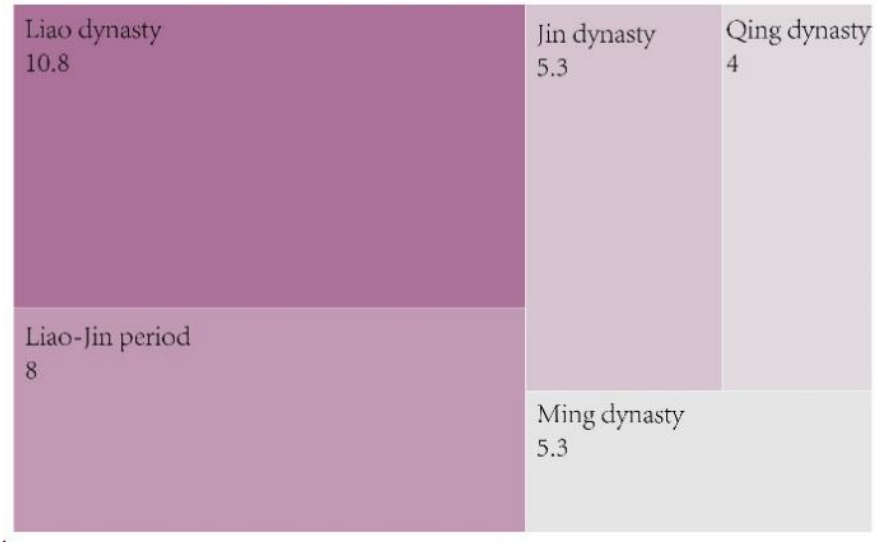

Fig. 5. Average Number of Decoration Types per Pagoda for Each Dynasty

The Liao Dynasty has the highest number of decoration types in its pagodas, with an average of nearly 11 types per pagoda. This is nearly twice the number in the Jin Dynasty and Qing Dynasty, and almost three times the number in the Ming Dynasty. Among them, there are two pagodas from the Liao-Jin period (Shuangtagou Pagoda and Anshan Silver Pagoda) whose specific construction dates are unknown. However, based on the average number of decoration types per pagoda for each dynasty, it is found that the number of decorations in these two pagodas falls between that of the Liao Dynasty and the Jin Dynasty, placing them in an intermediate position. Therefore, based on the number of decorations on the pagodas, it is not possible to determine whether they belong to the Liao Dynasty or the Jin Dynasty. However, this observation aligns with the inference made by relevant scholars that these pagodas belong to the "Liao-Jin period."

3.4.3 The Relationship between Dynasties and Decorations

By analyzing the relationship between decoration types and dynasties, a visualization using a grouped bar chart can be chosen. The horizontal axis represents different categories of decorations, while the length of the vertical bars represents the number of decorations in the pagodas. Different colors can be used to differentiate the pagodas from different dynasties. Moving the mouse over a specific decoration will display detailed information about that decoration.

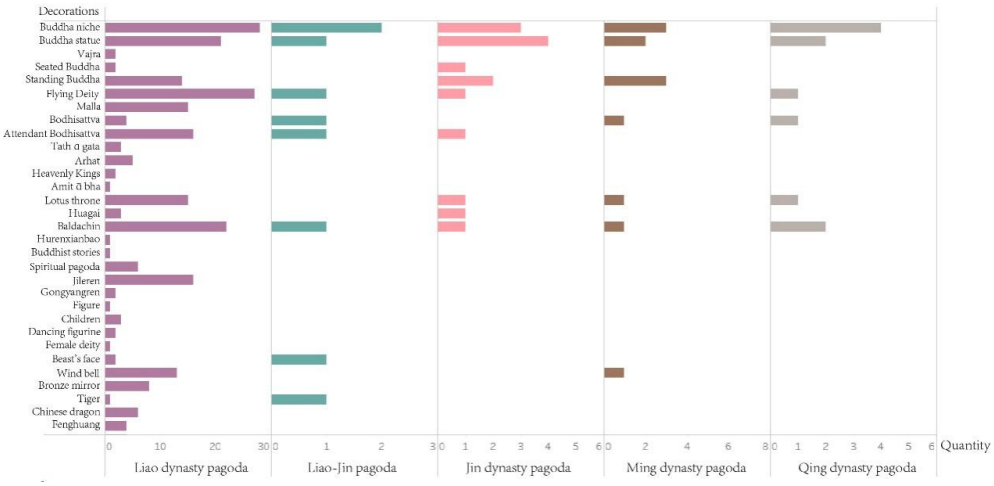

Fig. 6. The Relationship between Dynasties and Decorations

According to the visualization chart, the Liao Dynasty pagodas have unique decorations such as Vajra, Guardians, Buddha, Arhats, Heavenly Kings, Infinite Life Buddha, Arch door, Hurenxianbao, Buddhist Stories, Spiritual pagodas, Jileren, Gongyangren, Children, Dancing Figures, Chinese dragons, Phoenixes, Horses, Elephants, Fish, Peacocks, Golden-winged Birds, Flowers, and Treasure Vases. The Jin Dynasty pagodas have unique decorations such as Camel Humps, Brick Carved Brackets, Brick Carved Flying Creatures, and Brick Carved Lotus. The Liao-Jin pagodas have unique decorations such as Lotus Leaves, Water Plants, and Herons. The Ming and Qing Dynasty pagodas do not have any unique decorations. Common decorations found in all dynasties include Baldachin, Buddha niche, Buddha Statues, and Bodhisattvas.

Through the visualization chart, it can be observed that some decorations have a "discontinuous" usage pattern across different dynasties. For example, the bronze mirror, the wind bell and Jileren. Bronze mirrors only appear in 8 Liao Dynasty pagodas and are absent in other dynasties. Wind bells appear in 13 Liao Dynasty pagodas and 1 Ming Dynasty pagoda. In Buddhism, bronze mirrors are considered as "mirrors of the mind" or "mirrors of the Dharma," while wind bells are often used as a medium to transmit Buddhist teachings. The extensive use of these bronze mirrors and wind bells in Liao Dynasty pagodas indirectly reflects the importance given to pagodas and Buddhism during that period, as well as the level of metallurgy and craftsmanship at that time. Jileren, which represents the joyful dance scenes in the world of Buddhas and Bodhisattvas, appear in all 16 Liao Dynasty pagodas but are absent in later dynasties' pagodas in Liaoning province. The depiction of Jileren was an important subject in mural paintings during the Sui and Tang dynasties, and it was widely used in palaces and temples. Therefore, it is speculated that the significant presence of performer images in Liao Dynasty pagodas was influenced by the Tang Dynasty.

4 Conclusion

This article takes a visualization approach to studying the pagodas in Liaoning province. The detailed data of the pagodas in Liaoning province was collected, and through the cross-analysis of different categories of data, several conclusions were drawn. For example, by using data visualization, the article validates previous scholars' conjectures about the dynasties to which two pagodas belong. Based on the materials and quantities of the pagodas, the research makes speculations about the distribution of brick kilns in various dynasties in Liaoning. This research also discovered that the decoration of Jileren only appears on pagodas from the Liao Dynasty, while the Jin Dynasty pagodas, which follow the architectural style of the Liao Dynasty pagodas, do not feature J decorations. The article further explores other connections between the pagodas' materials, decorations, dynasties, and regions. This research provides data references and theoretical foundations for subsequent studies in the fields of architecture, art history, and religious studies.

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