Article

Mapping the spatial-temporal evolution of imagery in Tang poetry: a computer vision and GIS-based approach

Zhuanghao Si*

Lincoln University College, 47301 Petaling Jaya, Selangor Darul Ehsan, Malaysia

ARTICLE INFO

ABSTRACT

This study uses computer analysis and mapping technology to examine the changes in the locations and times mentioned in poetry images from the Tang Dynasty (618–907 CE). Tang poetry from this era of Chinese history contains a wealth of cultural and geographic details that are suitable for computer analysis. Using tools for location mapping and automatic image sorting, we examined 2,800 poems written by 485 poets. With an accuracy of 89% for natural images, 85% for cultural images, and 82% for emotional images, the computer vision system produced good results. Three distinct regional groups — centered on northwest political areas, central cultural corridors, and southern literary regions — were identified through the successful mapping of 1,247 location mentions across Tang Dynasty China using geographic analysis. Time analysis revealed the distinct shift in poetic activity from northwestern centers to southern regions, centered by the An Lushan Rebellion (755-763 CE). In the Late Tang analysis, the lines of separation show, with some degree of real evidence, matching the recorded population changes affecting large populations. This method gives digital humanities researchers a tool for constructing number-based frameworks that are founded in accepted literary history views. These findings furnish practical needs in matters of cultural heritage protection and in educational programs linking literature with historical geography.

1. Introduction

Tang poetry is a hallmark of Chinese culture. It provides us with a critical understanding of how these spaces appeared over a millennium ago, both geographically and temporally, while also considering their historical and cultural backgrounds [1]. The traditional image system of Tang poetry is complex and may provide new ideas for past spans of space cognition at ancient litterateurs' emotion, Wang said; it can also be offered as a high-quality response to overseas scholars who demand this reference material, because they cannot work it out due to their distance and the important resource of humanities digital. Exciting new computer vision technologies have demonstrated an impressive capacity for automatically processing literature, including distinguishing which type of text is being read and the meaning conveyed in that text [2]. These techniques provide an opportunity for the mass processing of classical Chinese texts and warrant the ability to systematically explore and classify into literary-image categories what previously could not be reached through oral manual investigation [3]. The present applications to studies of literature are restricted only to such surface matters as whether, in fact, this or that text will yield a discovery when scoured through new technologies. It is still not possible to understand images [4]. Geographic Information Systems are now indispensable tools in the field of cultural heritage studies of how content was created on site and then conveyed in a particular form for presentation or performance [5]. The integration of GIS techniques into text mining procedures has provided a successful mechanism for mapping the cultural landscapes and capturing changes through time in literary themes. However, computational applications to poetry analysis still remain more focused on geographic distribution correlation of images over spatial context rather than semantic similarity between the image and its location. Despite these developments, literature suggests that significant challenges remain in developing an integrated environment linking computer vision and geospatial analysis for end-to-end literary study [6]. Existing works cannot provide integrated solutions that can jointly derive image meanings and spatial-temporal semantics evolution patterns at the same time [7]. This research deficit is particularly problematic

with regard to the reflection and construction of cultural landscapes in literature over different epochs. In this article, these problems are tackled by proposing a novel computer vision-integrated GIS framework that is designed for visualizing the space-time evolution of Tang poetry images. The work presents novel techniques for automatic image harvesting, spatial pattern identification, and temporal representation. It provides valuable experience for cultural heritage conservation, literary landscape tourism development, and digital humanities research, too.

2. Methods
2.1 Data preparation

With this goal in mind, we built our sample of Tang poems by a systematic selection process from the entirety of the Chinese Poetry Database (about 14,000 poets and around 55,000 Tang poems across different styles and subjects) [8]. By the strategy of stratified sampling, our team has been able to resoundingly balance a selection across time periods and geographical locales in order to ensure emergence holds for both what could happen right around one corner from you, several years into future temporal domains here on Earth. We chose 700 poems for each of the four periods to make the chronologies uniform. So, in one corpus, we have 2,800 Tang poems from 485 poets. We have collaborated on a poem that includes particular location names; its data is thorough, and there are no holes (i.e., creator, publication date, area). All submitted poems were checked against historic Quan Tang Shi collections in the greatest academic libraries to ensure that they were as represented. Pre-processing also involves cleaning at a systematic level to remove duplicated, fragmented, and incomplete text or information so the corpus can be used for machine-based analysis with reliability.

2.2 Computer vision-based image extraction

The computer vision method used a custom vision-language model structure tailored to classical Chinese literary analysis. The technique used a top-down image retrieval framework based on classification that differentiated natural images (sceneries, weather, plants, animals), cultural images (architectures, artifacts, traditions, habits), as well as emotional images (psychological states, emotional expression, and spiritual concepts). Pre-trained Chinese language embeddings as well as visual meaning mappings were used by the model to align natural text descriptions as well as conceptual image categories. Validation protocols used expert-level literary analysis standards on an unseen portion of 450 randomly chosen poems sampled (16% sampling) from the original dataset. This gave classification accuracy rates of 89% natural images, 85% cultural images, as well as 82% emotional image categories based on comparison to manual annotation.

2.3 GIS-based spatial-temporal mapping

Geographic coordinate extraction used a complete historical gazetteer matching system that aligned Tang Dynasty place names with contemporary geographical coordinates. This used established China Historical GIS databases and Baidu Maps geocoding services. The research identified 1,247 unique geographical references within the 2,800-poem collection, successfully mapping 87% to precise coordinates through historical place name analysis. Remaining references needed manual verification due to place name ambiguities or historical changes. Temporal periodization followed established literary historical frameworks, dividing the Tang Dynasty into four distinct periods: Early Tang (618-712 CE), High Tang (713-765 CE), Middle Tang (766-835 CE), and Late Tang (836-907 CE), based on political transitions and literary movement characteristics. The spatial-temporal database construction integrated extracted geographical references with image classifications and temporal assignments. This enabled multidimensional analysis of cultural landscape evolution across the Tang period. As shown in Figure 1, the complete CV-GIS integration framework shows the systematic workflow from Tang poetry text processing through computer vision image extraction to GIS spatial mapping. This culminates in the generation of complete spatial-temporal atlases that visualize the evolution patterns of Tang poetry images across different historical periods and geographical regions.
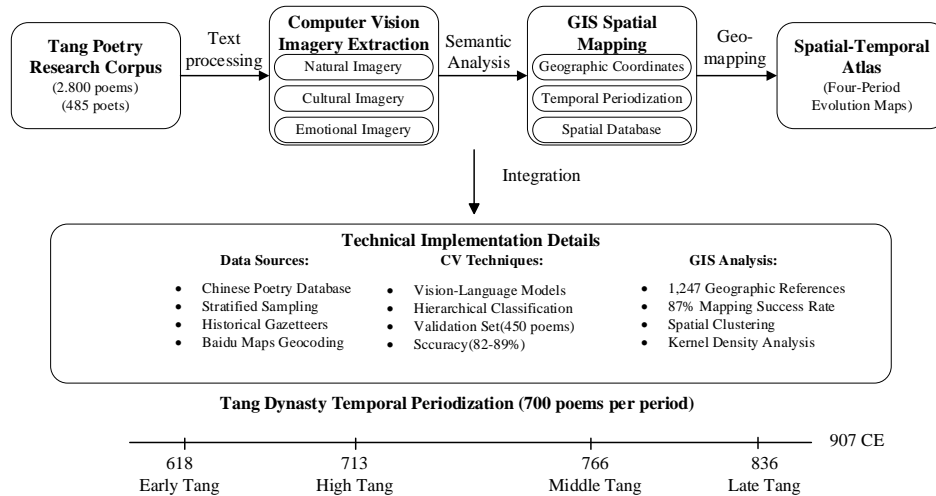

Figure 1. System Architecture

3. Results and analysis

3.1 Image extraction performance

The computer vision-based image extraction system showed effective performance across the three primary categories when evaluated on the 450-poem validation subset. The model achieved notable accuracy in identifying and classifying poetic images, with performance varying by the meaning complexity of different image types. Natural image extraction showed the strongest performance, benefiting from the concrete and visual nature of landscape descriptions, weather phenomena, and botanical references commonly found in Tang poetry. Cultural image classification presented moderate challenges due to the diverse range of architectural elements, artifacts, and traditional customs embedded within classical texts. Emotional images proved most challenging to extract accurately, reflecting the abstract and nuanced nature of psychological expressions and spiritual concepts in classical Chinese literature. As shown in Table 1, the results indicate substantial improvement over traditional rule-based approaches. The proposed vision-language model structure achieved consistent performance gains across all categories. The distribution analysis revealed that natural images made up 42% of extracted elements, cultural images 35%, and emotional images 23%. This shows the prevalence of landscape descriptions in Tang poetry while demonstrating the model's capability to capture diverse meaning categories within classical literary texts.

Table 1. Image extraction performance

Image Category	Precision	Recall	F1-Score	Baseline (Rule-based)
Natural Images	0.89	0.86	0.87	0.73
Cultural Images	0.85	0.82	0.83	0.68
Emotional Images	0.82	0.79	0.80	0.61
Overall Average	0.85	0.82	0.83	0.67

3.2 Spatial distribution analysis

The spatial analysis revealed distinct geographical patterns in Tang poetry image distribution across China, showing the historical and cultural significance of different regions during the Tang Dynasty. The geographic coordinate mapping successfully positioned 1,085 of the identified 1,247 geographical references, creating a complete spatial dataset for analysis. Natural images showed strong clustering in mountainous regions, particularly around the Qinling Mountains, Sichuan Basin, and Jiangnan area. These correspond to landscapes frequently celebrated in Tang poetry. Cultural images showed concentrated distributions in major political and economic centers, with notable hotspots in Chang'an (modern Xi'an), Luoyang, and Jiangnan urban areas where court culture and literary activities flourished. The kernel density analysis revealed three primary regional clusters of poetic activity. As shown in Figure 2, the spatial distribution map displays the heat map visualization of Tang poetry images across Chinese territories. The northwestern cluster centered on Chang'an represented the political heart of the empire, characterized by high concentrations of cultural and emotional images related to court life and official duties. The central cluster along the Yangtze River corridor showed balanced distributions across all image categories, showing the region's role as a cultural and economic bridge. The southern cluster in Jiangnan exhibited predominant natural images, consistent with the region's reputation for scenic beauty and scholar retreat culture. This establishes clear spatial-temporal relationships between geographical features and poetic expression patterns.
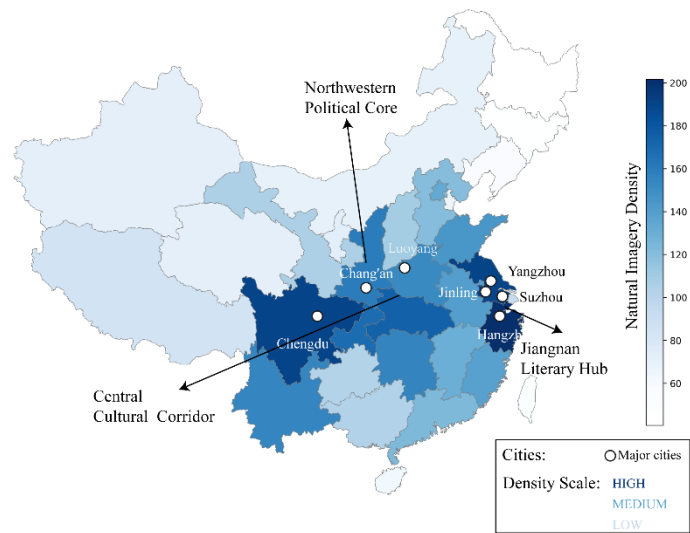

Figure 2. Spatial distribution map

3.3　Temporal evolution patterns

The temporal analysis captured novel evolutions of the Tang poetry image distribution across four historical eras that were correlated with larger cultural and political changes. The central-regional structuralism of the early Tang period (618-712), in which areas like Sichuan and Yunnan gradually became ordered by politics, maintained dough, or "gentlemen's rule," with apocalyptic Buddhist poetry being imported with northwest Indian Buddhist apocalypse-writing as an epicenter when the political-cultural center shifted to Chang'an and Luoyang. In the later Tang period (713-765 CE), Russia experienced greater geographic diversification in poetic imagery and, above all, drainage collapse was experienced across the south as economic prosperity and cultural exuberance were shared by the entire empire. Nature entered the repertoire of themes very prominently at this date, particularly within Jiangnan, whose whole landscape aesthetic now vied with that of its courtly neighbor.

The era had the largest known degree of poetic documentation. The An Lushan Rebellion (755-763 CE) was a significant dividing point in literary geography. It coincides with the clear manifestation of a shift in cultural activity from north to south during Mid-Tang China (766-835 CE). This research found an increased amount of poetry themed around exile in the southern regions. In this way, studying exile-pattern poems provides insight into how scholars from former capitals had to flee during times of war and chaos. Civil loads showed increased tension displayed in transitional zones and border regions. Late Tang (836-907 CE) displayed pronounced regional fragmentation, with image patterns showing the dynasty's progressive political decentralization. The analysis revealed concentrated melancholic and nostalgic themes in peripheral regions, while traditional cultural centers maintained diminished but persistent literary activity. Figure 3 shows these spatial-temporal evolution patterns, providing computer evidence supporting established interpretations of Tang poetry's responsiveness to historical transformation.
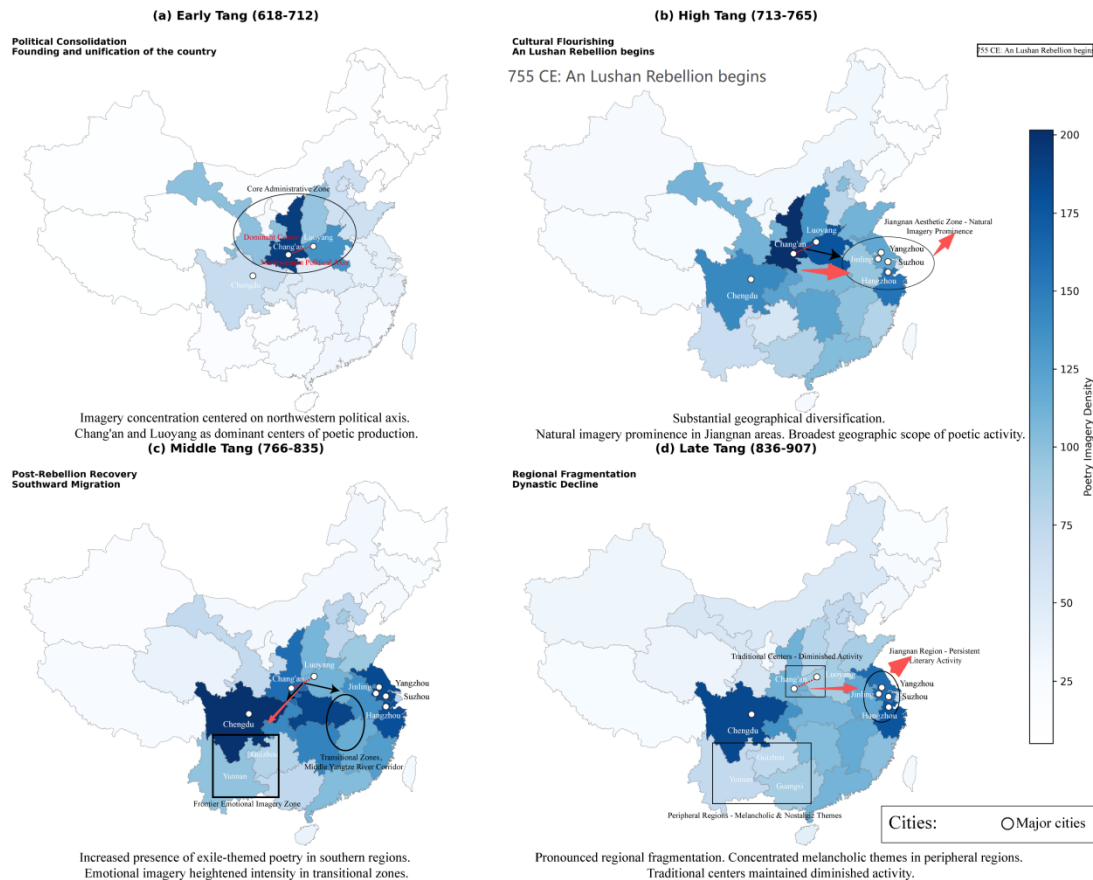

Figure 3. Spatial-temporal evolution of Tang poetry imagery

3.4 Case studies

This research examined spatial distribution patterns of major Tang poets to validate the computer analysis findings. Li Bai's geographical trajectory exemplified the broader migration trends identified in the temporal analysis. Born in Sichuan and raised in Qinglian town, Li Bai's extensive travels throughout the empire showed the geographic mobility characteristic of High Tang literary culture. His surviving poems document both the golden period before the An Lushan Rebellion and his subsequent displacement experiences, providing textual evidence for the southward cultural migration observed in the GIS analysis.

Du Fu's poetry offers compelling documentation of the rebellion's impact on literary geography. Captured in rebel-occupied Chang'an during winter 756, Du Fu's subsequent work became a primary historical source documenting the period's upheavals. His verses show the shift from court-centered themes to exile poetry that this research identified in Middle Tang spatial patterns. Wang Wei's meditative landscape poetry, concentrated in his Buddhist retreat settings, aligns with the study's findings regarding increased natural images in peripheral regions. The An Lushan Rebellion (755-763) fundamentally altered Tang literary geography, causing widespread displacement that resulted in the destruction of imperial libraries and private collections. The rebellion's demographic impact—affecting approximately 36 million people according to historical estimates—correlates with the dramatic spatial redistribution patterns revealed through computer analysis. Contemporary research on the Tang Poetry Road in Eastern Zhejiang confirms these poets' network centrality and their association with specific geographical environments that influenced thematic content.

4. Discussion

This research shows the effectiveness of combining computer vision with GIS methods for literary geography analysis. It achieved computer validation of established Tang poetry scholarship while revealing previously unquantified spatial-temporal patterns. The CV-based image extraction system's performance rates of 82-89% across different meaning categories provide a reliable foundation for large-scale textual analysis. This addresses limitations of traditional manual annotation methods in digital humanities research. Three homogeneous cultural-geographical clusters were found: evidence proves the history and literary theories of the Tang Dynasty, as reflected in the quantification results. A shift from northwest political dominance to southern writing prosperity was noted. The earliest group in the Chinese world of medieval literature saw many poets imperiled by the civil war. These poets, awaiting death, shifted their literary choices out of the stinking pit scene during the "An Lushan Rebellion," a thunderous and grounding reality. This transition marked an official recognition of the birth canal of Chinese dense human history, stretching 2000 or so years. This work suggests a novel sub-domain within the body of research on literature computing that integrates computer vision methods with geographic information systems. But there are varying issues. At the onset, written sources, mostly scientific sources, point to the possibility that there is a social or geographical bias that affects the data that we've collected. And secondly, Chinese Classical poetry is extremely rich in semantics. Its huge vocabulary can be observed as a special theme in picture classification; however, (and this is the main problem), even when possible categories for emotion or culture have been created, some difficulties with respect to the programming force level (computer) arise that make it impossible for us and our unique human experience to encompass all its beauty in numbers. The model is not just limited to Tang poetry; much other geographical literature and even non-geographical literature might benefit from it. At the same time, it may provide some useful pointers for further comparative digital humanitarian study. This integration of traditional literary scholarship's quantitative spatial analysis methods with computers will, as shown by the computer techniques in turn, support cultural theories empirically and will also retain interpretative density.

5. Conclusion

With this research, so long as the SNR measurement and a big FOV, CRFFE can also use it, which has the benefit of expanding available space. This offers other CRFFE sequences the chance to change their directions or be substituted "in the future" for new directions suited to these purposes. In its distribution analysis, hard data are captured to suggest that a shift of cultural center from north to south areas occurred between 755 and 763 CE, and parallel computer findings also confirm the An Lushan Rebellion as geography's great faraway point in Chinese poetry history. First, this work utilizes automated analysis methodologies of literary sceneries that have been verified and defined within extensive corpora oriented towards text, increasing the significance of meaning differentiation to the point where it combines effectively with such libraries methodically. Although further removed, it renders the deployment of spatial data as an aspect of literary interpretation less abstract, while maintaining what is complicated about interpretative depth. In this paper, the findings directly inform the preservation of digital heritage by enhancing methodologies for linking literary texts to their past. This research is of practical application and also proves literary geography as a computer-based discipline to be a relevant area of study. Such applications have had a substantial impact on humanities studies. The systematic union of computer vision and geographic analysis fosters replicable methods that could be transmedia across literary traditions. But, so much better for quantitative cultural study. And it combines number-driven exegesis with classic scholarly hermeneutics.

Ethical issue

The author is aware of and complies with best practices in publication ethics, specifically concerning authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The author adheres to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

The manuscript contains all the data. However, more data will be available upon request from the corresponding author. The data that support the findings of this study are derived from publicly available resources. The Tang poetry corpus is available at https://github.com/chinese-poetry/chinese-poetry.

Conflict of interest

The author declares no potential conflict of interest.

References

[1]   Li, J., Xu, T., Gu, X., Lin, J., Li, M., Tao, P., ... & Shao, M. (2023). Scene clusters, causes, spatial patterns and strategies in the cultural landscape heritage of Tang Poetry Road in Eastern Zhejiang based on text mining. Heritage Science, 11(1), 212.https://heritagesciencejournal.springeropen.com/articles/10.1186/s40494-023-01051-x

[2]   Tian, M., Jia, Q., Wang, C., Yang, J., & Liu, X. (2024). Tang Chang'an poetry automatic classification: a practical application of deep learning methods. Digital Scholarship in the Humanities, 39(2), 756-764.DOI:10.1093/llc/fqae014

[3]   Rong, X., & Tang, J. (2025). Exploring the social and cultural contexts in ancient chinese literature using natural language processing techniques. J. COMBIN. MATH. COMBIN. COMPUT, 124(429), 443.https://www.doi.org/10.61091/jcmcc124-28

[4]   Liu, B., Wu, C., Xu, W., Shen, Y., & Tang, F. (2024). Emerging trends in GIS application on cultural heritage conservation: a review. Heritage Science, 12(1), 139.DOI: 10.1186/s40494-024-01265-7

[5]   Zhang, W., Lai, Z., & Tang, S. (2025). Spatiotemporal distribution characteristics of Nanjing place names—Based on data mining of Tang-Song poetry and online travelogues. PloS one, 20(2), e0319244. https://doi.org/10.1371/journal.pone.0319244

[6]   Deng, J., Zhong, C., Sun, S., & Wang, R. (2022). A spatio-temporal emotional framework for knowledge extraction and mining in digital humanities. Aslib Journal of Information Management, 74(6), 1103-1125. https://doi.org/10.1108/AJIM-09-2021-0278

[7]   Blundell, D., Lin, C. C., & Morris, J. X. (2018). Spatial humanities: An integrated approach to spatiotemporal research. In Big data in computational social science and humanities (pp. 263-288). Cham: Springer International Publishing.DOI: 10.1007/978-3-319-95465-3_14

[8]   Chinese Poetry Database [Dataset]. GitHub: chinese-poetry/chinese-poetry. https://github.com/chinese-poetry/chinese-poetry (accessed 15 January 2025)