

Postprint: Quantitative Analysis and Visualization of Warfare in Zuo Zhuan Using Social Network Analysis

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Date: 2023-04-01T00:00:00+00:00

Abstract

[Purpose/Significance] The development of information technology has facilitated the extensive application of digital humanities in the social sciences and humanities, leveraging convenient and efficient computational techniques to extract latent information from massive data resources and unstructured texts, and presenting it to users in a more intuitive and clear manner. [Methods/Process] This study takes the wars described in Zuo Zhuan as its research object, extracting the strategic offensive and defensive parties of each war from the obtained war-related sentences. From the perspective of digital humanities, it explores the feasibility of employing social network analysis methods to mine changes in the Spring and Autumn period warfare patterns. On this basis, the vassal states of the Spring and Autumn period are divided into communities based on war cooperation and confrontation relationships, with each community and core state subjected to detailed analysis and discussion. Simultaneously, three technologies—HTML, CSS, and E-Charts—are utilized to dynamically visualize the wars in Zuo Zhuan. [Results/Conclusion] This research provides a method for extracting Spring and Autumn period war information from unstructured Zuo Zhuan texts and organizing it into quantifiable data. It demonstrates the feasibility of displaying diplomatic relations among vassal states during the Spring and Autumn period from the perspective of warfare, while also showcasing both the feasibility and tremendous potential of digital humanities technology in humanities and historical research.

Full Text

A Research on the Visualization and Metric Analysis of Wars in *Zuo Zhuan* Based on Social Network Analysis

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Abstract:

[Purpose/Significance] The development of digital humanities has driven the widespread application of information technology in the social sciences and humanities, enabling the extraction of potential information from massive data resources and unstructured texts through convenient and efficient computational techniques, and presenting it to users in a more intuitive and clear manner. **[Method/Process]** This study takes the wars described in *Zuo Zhuan* as its research object, extracting the strategic offensive and defensive parties for each war from the obtained war-related sentences. From the perspective of digital humanities, it explores the feasibility of using social network analysis to mine changes in the war patterns of the Spring and Autumn Period. Based on this, the vassal states of the Spring and Autumn Period are divided into communities according to their cooperative and confrontational relationships in wars, with each community and core state analyzed and discussed individually. Additionally, three technologies—HTML, CSS, and E-Charts—are employed to dynamically display the wars in *Zuo Zhuan*. **[Result/Conclusion]** This paper provides a method for extracting war information from the unstructured text of *Zuo Zhuan* and organizing it into quantifiable data. It proves feasible to demonstrate the diplomatic relations between vassal states during the Spring and Autumn Period from the perspective of war, while also showcasing the feasibility and tremendous potential of digital humanities technology in historical research.

Keywords: *Zuo Zhuan*; digital humanities; social network analysis; war

Classification Number: G250

DOI: 10.13266/j.issn.0252-3116.2020.06.011

1 Introduction

As a new interdisciplinary research field, digital humanities has attracted increasing attention from Western humanities and computer science communities [1]. Although some controversies remain regarding its development, the research trend of digital humanities is unstoppable [2]. The establishment of digital humanities research institutions worldwide, regular conferences on digital humanities, and funding support for digital humanities projects all demonstrate that the achievements of digital humanities and its impact on research paradigms in humanities and social sciences are undeniable [3].

During the Spring and Autumn Period, ritual order collapsed, and the vassal

states under the Zhou Son of Heaven maintained survival or promoted their hegemonic ambitions through various diplomatic forms including warfare, alliances, marriages, court visits, and bribery. War was the most important and direct means of hegemonic competition. *Zuo Zhuan* records over seven hundred wars of varying scales from the first year of Duke Yin (722 BCE) to the fourth year of Duke Dao (463 BCE). These wars were not merely struggles between two states but also “diplomatic wars” among vassal states [4].

This study selects *Zuo Zhuan* as its research object, extracting sentences describing wars as raw data, and combines digital humanities technology with social network analysis theory to conduct empirical research on wars during the Spring and Autumn Period. It reveals the cooperative and confrontational relationships between vassal states and the evolution of relationship intensity, providing empirical evidence for research on the history of hegemonic competition during the Spring and Autumn Period.

2 Literature Review

The theoretical foundation of social network analysis originates from graph theory and represents a product of interdisciplinary integration among psychology, sociology, statistics, and systems science. Social network analysis emerged from the structural focus of renowned British anthropologists such as L. Rainie [5]. Regarding applications of social network analysis, C. Wetherell believes network analysis has tremendous potential in historical analysis [6]. Scholars both domestically and internationally have conducted extensive research applying network analysis to humanities and history. In the field of information science, social network analysis has been used for context-sensitive information search and recommendation, expert discovery and domain queries, content organization, tracking and monitoring, and behavior prediction [7]. In the historical domain, social network analysis similarly serves functions of community discovery and knowledge discovery. Dr. Xu Chao from Nanjing Normal University studied *Zuo Zhuan* from a network science perspective, constructing a social network of Spring and Autumn figures to explore the social history and key individuals reflected in *Zuo Zhuan* [8]. Zhao Wei applied social network analysis to examine character relationships and social networks in the “Great Wave” trilogy, demonstrating the usability of this method [9]. Qin Changjiang used social network analysis to comprehensively construct a knowledge map of Chinese agricultural history, examining the discipline’s academic system, structure, and relationships with adjacent disciplines [10]. Yan Chengxi and others analyzed the political network of the Song Dynasty using social network analysis [11]. L. Klein employed digital methods, using the *Digital Edition of the Papers of Thomas Jefferson* as primary archives, to excavate African American historical voices from archival materials on slavery [12].

When historians study wars recorded in *Zuo Zhuan*, they focus on several aspects: First, analyzing important individual battles that significantly impacted warfare methods, hegemonic patterns, and state status. For example, Wang

Changmin argues that the Battle of Hong marked an important shift in ancient Chinese warfare methods, transitioning from chariot warfare to infantry combat, and analyzes Duke Xiang of Song's defeat as resulting from his adherence to ancient war rituals and superstitious belief in divine assistance [13]. Zhang Yang examines the Battle of Chengpu to analyze the formation and establishment of the Wei-Jin alliance: Jin's inherent strength, Wei's position as not being a core interest of Chu in the Jin-Chu rivalry, and the Wei-Jin alliance's role in restraining threats from Chu and Zheng to Jin [14]. Wang Shufang analyzes the causes of the Battle of Xiao between Qin and Jin from the unearthed text *Xinian*, arguing that Zheng's "submission to Qin but not Jin," its acceptance of three Qin officers, and rejection of Jin's demands intensified Qin-Jin contradictions and triggered the battle [15]. Second, comprehensively analyzing all wars throughout the Spring and Autumn Period to examine diplomatic relations and social structural development between two states along a timeline. For instance, Wu-Chu relations were primarily manifested through warfare, mostly occurring in the middle and late Spring and Autumn Period when social structures and ideologies were also changing [16]. Third, studying war concepts and war culture. Kang Wei conducts in-depth analysis of the "ritual observance" phenomenon in Spring and Autumn warfare from three aspects: ceremony, benevolence, and trustworthiness, pointing out that ritual observance in Spring and Autumn wars included not only divination and ancient war customs but also moral principles of benevolence and righteousness 贯穿 throughout warfare [17]. Zhuge Ruiqiang conducts in-depth research on military strategies in Spring and Autumn warfare, noting that certain tactical methods in the Battle of Xiao tending toward "deceptive" military characteristics reflected the collapse of ancient military rituals and deepening understanding of war patterns [18]. Fourth, analyzing war descriptions and terminology from literary perspectives to explore the development and evolution of ancient Chinese literature and art. Han Xi subdivides war and killing verbs related to prepositions in *Zuo Zhuan* and analyzes their military ideological connotations based on co-occurring prepositions and their positional relationships [19]. Tian Xiaoxia analyzes *Zuo Zhuan*'s literary techniques in war descriptions from a narrative perspective, noting its skill in selecting and organizing materials around themes and often focusing on other aspects related to warfare [20].

Overall, as a research method in digital humanities, social network analysis has proven feasible for humanities research, providing a new computational perspective for exploring and solving related humanities issues. Regarding war events recorded in *Zuo Zhuan*, humanities scholars typically analyze war processes and their impacts on society and hegemonic patterns from qualitative perspectives, with few conducting quantitative analysis and visualization of wars in *Zuo Zhuan*. Network analysis in humanities and social sciences research follows the steps of "unstructured corpus → structured entity representation → entity digitization → relationship visualization → content analysis" [21]. This study further examines wars described in *Zuo Zhuan* during the Spring and Autumn Period according to rules proposed by T. Deryc et al. for network analysis in digital hu-

manities research. Starting from original text content, it proceeds through data structuring, dataset extraction, network construction, content analysis based on networks, and finally digital presentation. This approach yields both micro-level war data and macro-level new revelations and analyses of Spring and Autumn warfare based on networks constructed from these micro data.

3 Data Sources and Processing

Analyzing wars between vassal states during the Spring and Autumn Period requires extracting, summarizing, and organizing war times, events, and participating states.

3.1 Data Sources

After comprehensive examination of war records in *Zuo Zhuan* based on the “Chronological Table of Wars in *Chunqiu Zuozhuan*” in Zhu Baoqing’s 1991 edition of *Zuoshi Bingfa* and the 2003 edition of *Chronological Table of Wars in Chinese History*, Deng Yong obtained the “Table of Wars in *Chunqiu Zuozhuan*” [22], currently the most comprehensive summary of wars depicted in *Zuo Zhuan*. In Deng Yong’s “Textual Research on Spring and Autumn Wars,” clear criteria for determining whether an event constitutes a war are provided: organized violent struggle between groups; deployment of armed forces. Based on these criteria, he corrected repetitions, confusions, and omissions in the “Chronological Table of Wars in *Chunqiu Zuozhuan*” and *Chronological Table of Wars in Chinese History* caused by inconsistent statistical standards. The final table includes for each war: time, war name, war terminology, description, and index. Table 1 provides partial examples from the “Table of Wars in *Chunqiu Zuozhuan*” [22]. The time field includes three chronological forms: Lu state chronology (the chronology used in *Zuo Zhuan*), Zhou dynasty chronology, and Western calendar. For display convenience, this study uniformly uses Western calendar chronology. The war name field is determined by the author based on important vassal states among the warring parties and war terminology. War terminology refers to war verbs described in *Zuo Zhuan*, which usually determine the nature of wars. War descriptions follow the basic pattern: “At a certain time, Party A fought Party B at a certain place for a certain reason, with a certain outcome.” The index provides page numbers from *Shisan Jing Zhushu* published by Zhonghua Book Company and *Chunqiu Zuozhuan Zhengyi* published by Peking University Press for readers to consult the original texts. Notes supplement war sources and corrections to the “Chronological Table of Wars in *Chunqiu Zuozhuan*” and *Chronological Table of Wars in Chinese History*.

To completely extract participating vassal states for each war, this study uses the base text of *Chunqiu Jingzhuan Yinde* compiled by Mr. Hong Ye as the data source for the full text of *Zuo Zhuan*. *Chunqiu Jingzhuan Yinde* is one of the 64 types and 81 volumes of ancient Chinese classics indexes in the *Hanxue*

Yinde Congkan published by the Harvard-Yenching Institute's Index Compilation Office from February 1931 to March 1950. Its main function is to provide word-by-word indexing of *Chunqiu Jingzhuan* and distinguish entities with identical characters (see Table 2). The compiler distinguishes different individuals referred to as “Xianzi” and categorizes their affiliated vassal states, listing specific sentences where they appear in *Chunqiu Jingzhuan*. This allows readers to determine a figure's affiliated vassal state through this index.

3.2 Data Processing

Based on the time, war name, and war description provided in Table 1, all sentences describing each war were matched with the full text of *Zuo Zhuan*. A total of 738 wars were obtained, and the offensive and defensive parties for each war were extracted and verified based on this full-text data. The specific processing flow is shown in Figure 1 [Figure 1: see original paper].

According to the war time, war name, and war description provided in Table 1, the war descriptions basically contain the “participating members” of each war. These “participating members” are typically expressed in three ways: First, by using participating vassal states, such as in “In autumn, eighth month, people of Ji attacked Yi,” where “Yi” refers to the object of attack, “the state of Yi.” Second, by mentioning participating figures without specific vassal states, such as in “In summer, fifth month, the Earl of Zheng attacked him because Duan rebelled, defeated Duan at Yan, and Duan fled to Gong,” which mentions “Earl of Zheng” and “Duan” as figure titles. The story of Zheng Bo defeating Duan at Yan is well-known, referring to the struggle between Duke Zhuang of Zheng and his half-brother Gongshu Duan, which was actually a civil war in the state of Zheng. Third, by using war locations to indicate participating states, such as in “People of Ju entered Xiang and returned with the Jiang clan,” where “Xiang” according to *Chunqiu Jingzhuan Yinde* refers to a place in the state of Lu, thus “People of Ju entered Xiang” can be viewed as Ju's invasion of Lu. Based on such rules, Spring and Autumn vassal state names, personal names, and place names were automatically extracted using matching methods. After extraction, cases where war participants were represented by figures or locations were manually verified and supplemented according to *Chunqiu Jingzhuan Yinde*, ensuring that participating parties for each war were represented by vassal state names.

Finally, strategic offensive and defensive parties in wars were distinguished. Based on Zhang Qiuxia's classification of war trigger words in *Zuo Zhuan* [23], this study distinguished war offensive and defensive parties (see Table 3). In a sentence, apart from defensive verbs, the party before the war verb is the strategic offensive party, and the party after is the strategic defensive party. For example, in the sentence “Lu's army defeated Song's army at Huang,” the war trigger word is the result verb “defeated,” and “Lu” appears before “defeated,” making it the strategic offensive party, while “Song” appears after, making it the strategic defensive party. Based on this principle, a computer program automatically extracted war offensive and defensive parties.

However, automatic extraction based on war trigger word positions produced errors due to the diversity of classical Chinese expression. Therefore, after automatic extraction, manual verification was conducted. During manual verification, several situations where automatic extraction of strategic offensive and defensive parties was impossible were summarized, as shown in Table 4. After manual verification, the final strategic offensive and defensive parties for each war in *Zuo Zhuan* were obtained, as shown in Table 5.

4 Visual Analysis of Spring and Autumn Period War Events

This study employs the mathematical expression form of social networks—community graphs—to characterize war cooperation and confrontation among vassal states during the Spring and Autumn Period. Community graphs consist of nodes (representing actors) and connections (representing relationships between actors). Historian Benedict Anderson, when describing nation-states, criticized community analysis for its limitations on localized, face-to-face interaction. He defined nation-states as imagined communities [6]. In this study, various vassal states of the pre-Qin period are treated as communities formed based on different relationships. Nodes represent vassal states of the Spring and Autumn Period, while connections represent war cooperation and confrontation relationships between them. Since diplomatic wars between vassal states occurred more than once, multi-valued community graphs are used to depict relationship strength. Undirected valued graphs represent war cooperation relationships between states, where two states belong to the same camp when conducting joint offensives or defenses. Connection thickness represents the frequency of war cooperation throughout the Spring and Autumn Period [24], as shown in Figure 2(a). Directed valued graphs represent war confrontation relationships, with arrow origins indicating strategic offensive parties and arrowheads pointing to strategic defensive parties. Thicker connections indicate more frequent attacks (or being attacked), as shown in Figure 2(b).

4.1 Overall Network Analysis

War cooperation and confrontation from 723 BCE to 463 BCE are discussed separately to explore the applicability of social network analysis to Spring and Autumn Period war relationship networks.

4.1.1 War Cooperation Network In a campaign, there are offensive and defensive parties, which are not necessarily independent states. Most wars during the Spring and Autumn Period involved alliances of multiple states attacking another state or alliance. These alliances constitute war cooperation networks—cooperation communities. Calculations show the average degree of the Spring and Autumn Period war cooperation network is 8.5, overall network diameter is 5, average clustering coefficient is 0.843, and average path length is 2.244, indicating that 84% of vassal states had 8-9 war cooperation partners. Compared to modern social networks, the high average clustering coefficient and low

average path length are primarily because this study's objects are states rather than individuals, and the long time span of the Spring and Autumn Period with constantly changing political patterns created diverse war cooperation.

Statistics reveal that 57 vassal states in *Zuo Zhuan* records had war cooperation relationships with other states. Degree is the sum of connections between a node and its neighbors and is one indicator of network node status and centrality. Table 6 lists vassal states participating in wars and their cooperation degree—the frequency of war cooperation with other states. The degree in Table 6 indicates how many times a state cooperated with others to launch wars or resist invasions. Jin had 28 cooperation instances with other states, the most among all vassal states. Chu ranked second with 26 cooperation instances. This is because hegemonic competition was continuous during the Spring and Autumn Period, with early competition between Qi and Chu, followed by prolonged Jin-Chu rivalry. Due to geopolitical characteristics, most Central Plains small states affiliated with political-military groups led by Jin and Chu [25]. Subsequent states like Lu, Song, Qi, and Zheng, also important powers, had cooperation degrees exceeding 20. However, most vassal states cooperated with others fewer than 5 times, and some had no war cooperation opportunities before being conquered.

4.1.2 War Confrontation Network Similar to war cooperation networks, calculations of the Spring and Autumn Period war confrontation network show an average degree of 3.336, overall network diameter of 5, average clustering coefficient of 0.322, and average path length of 2.684, indicating that 32.2% of vassal states had 3-4 war confrontation opponents (offensive or defensive).

In directed network graphs, degree divides into in-degree and out-degree. In the *Zuo Zhuan* war network, out-degree represents the number of times a node actively launched wars, while in-degree represents the number of times a node defended against attacks. Figure 3 [Figure 3: see original paper] lists vassal states with degree greater than 10. Chu has the largest in-degree and out-degree, indicating it participated in the most offensive and defensive wars. Large out-degree reflects Chu's military strength and hegemonic ambitions, while large in-degree represents concrete manifestations of Central Plains states' continuous invasions of Chu under the "expel the barbarians" slogan. Based on degree ranking, Spring and Autumn vassal states are divided into three zones: Zone I includes states with high degree, generally major powers whose out-degree exceeds in-degree, typically leaders that actively initiated wars and were main hegemonic competitors. Zone II states were not protagonists in Spring and Autumn wars, generally following major powers to attack relatively strong states, adopting diplomatic strategies of bribery, alliance, and court visits to preserve themselves. Zone III states were targets of major powers' attacks, with small out-degree and large in-degree, indicating they were frequently attacked but lacked strength to counterattack. Most small states during the pre-Qin period could not escape the fate of being conquered.

Considering that Spring and Autumn hegemonic competition divided into Qi-Chu rivalry and Jin-Chu contention, this study compares the diplomatic war patterns of these two periods. In 632 BCE, Duke Wen of Jin defeated Chu at Chengpu, preventing Chu's northward expansion and establishing Jin's hegemonic status [26]. Before Duke Wen's hegemony, there were Duke Zhuang of Zheng and Duke Huan of Qi; after him came King Zhuang of Chu and Duke Xiang of Song. Additionally, Chen Zhiping's *General History of China: Pre-Qin History* divides the Spring and Autumn Period into early and late periods at 621 BCE [27], while the decade from 632 BCE to 621 BCE saw Duke Wen of Jin's hegemony and relatively stable times with fewer wars. Therefore, the Battle of Chengpu is used as a dividing point to compare data before and after 632 BCE.

4.2 Changes in Spring and Autumn War Patterns Before and After the Battle of Chengpu

4.2.1 Changes in War Cooperation Networks War cooperation data from *Zuo Zhuan* was divided by time to construct network graphs shown in Figure 4 [Figure 4: see original paper]. Figure 4(a) shows the war cooperation network before the Battle of Chengpu. After network modularization, this period has relatively more modules because war cooperation often occurred among major powers, while small states rarely cooperated with others. War cooperation distribution was primarily geographically based, with frequent cooperation among Central Plains states. Chu, located in present-day Hubei's Jingshan area, was regarded as barbarian by Central Plains states and had relatively low status, cooperating only with surrounding small states. Figure 4(b) shows the war cooperation network after the Battle of Chengpu. Compared with the pre-Chengpu period, several major changes occurred: First, after module division, the number of communities decreased, meaning fewer war blocs. This is because direct war cooperation among vassal states was relatively limited before Chengpu, while after Chengpu, small states participated in hegemonic wars, attaching themselves to major powers and forming clear hegemonic camps. Second, Chu's direct war cooperation partners included not only barbarian states but also increasingly more Central Plains states, including Ji-surnamed and Jiang-surnamed states like Qin, Chen, Cai, Xu, and Wu. Third, changes occurred in Qin's war camp. Before Chengpu, Qin and Jin belonged to the same module, but after Chengpu, Qin joined Chu's war camp. Despite the diplomatic reputation of "Qin-Jin friendship," why did Qin's camp shift in the late Spring and Autumn Period? Zou Fudu argues this relates to Qin's participation in Central Plains diplomacy as a nomadic people needing acceptance and recognition. By the late Spring and Autumn Period, having experienced the glory of conquest, Qin's strategy shifted from attaching to Central Plains powers to actively launching wars, attempting to dominate the Central Plains through military force—reflecting the conquering desire of nomadic peoples [28].

Since significant changes occurred in network communities before and after

Chengpu, did the importance of each vassal state change? This study uses eigenvector centrality to measure changes in states' influence before and after Chengpu. Figure 5 [Figure 5: see original paper] compares eigenvector centrality of the top 17 vassal states before and after Chengpu. Eigenvector centrality measures node importance based on both the number and importance of neighboring nodes.

Figure 5 shows Jin's centrality consistently ranked first, indicating that throughout the Spring and Autumn Period, Jin cooperated with many states, and these cooperating states also frequently cooperated with others. Wei's centrality declined after Chengpu because after the second Mibing alliance (546 BCE), the international political pattern moved from the hegemonic era toward conclusion. Additionally, Wei's internal struggle between ducal power and ministerial power intensified, causing internal turmoil and severely weakening Wei's strength [29]. Qi's centrality decreased as Jin gradually rose and achieved hegemony, though Qi was a hegemon in the early period when its development was constrained by scarce domestic resources, requiring constant military expansion and relatively frequent war cooperation. Li Shaowen noted that Cai's rise and fall typified the fate of medium-sized Central Plains states: early Cai was a second-tier state whose neighbors couldn't threaten its survival, but in the late Spring and Autumn Period it was repeatedly invaded by Chu, and after constant relocations, when Chu re-established Cai, it had lost independent status [30]. Similar situations occurred in Chen, which ultimately became Chu's puppet.

4.2.2 Changes in War Confrontation Networks Based on war confrontation data, war confrontation networks were drawn, again divided by Jin's hegemony into pre- and post-Chengpu periods. Larger out-degree indicates larger nodes, showing more frequent active war initiation; larger in-degree indicates larger labels, showing more frequent resistance to invasions; thicker connections between two points indicate more frequent warfare between those states. Figure 6(a) [Figure 6: see original paper] shows that before Chengpu, main war-exporting states were Chu, Jin, Qi, and Lu. As major war exporters, they also suffered attacks and revenge wars from other states. Before Chengpu, Chu suffered the most attacks among all states, possibly because early Spring and Autumn Chu was regarded as a "barbarian state" by Huaxia states, and frequent wars against Chu were products of the "expel the barbarians" strategy. In the post-Chengpu period (mid-to-late Spring and Autumn), Qi, Jin, Lu, Song, and Chu experienced continuous internal contradictions and several civil wars. Some scholars argue Chu could no longer be regarded as a "barbarian state" during this period, so the "expel the barbarians" strategy lost value, transforming into hegemonic wars among major powers [31].

Post-Chengpu war confrontation patterns also changed. First, the number of confrontation communities increased from 4 to 5. The two confrontation communities centered on Qi and Lu before Chengpu split, contrary to the cooperation network where communities decreased after Chengpu. This reflects that in the

post-Chengpu period, powerful states accelerated conquering surrounding small states to expand their strength. Second, Wu and Yue joined the war community centered on Chu. Before rising, Wu and Yue submitted to Chu. After Wu's rise, it became Chu's strong eastern enemy, while Yue maintained friendly relations with Chu [32], leading to "ally with Wu to control Chu" and "ally with Yue to harass Wu" strategies. "Ally with Wu to control Chu" refers to Jin's strategy to break the Jin-Chu rivalry stalemate by using Wu to consume Chu, making the hegemonic situation favorable to Jin [33]. Chu countered with "ally with Yue to harass Wu" to suppress Wu. Thus, Wu-Yue struggles were, in a sense, continuations of Jin-Chu rivalry. Additionally, direct wars among Central Plains major powers increased. Moreover, in the mid-to-late Spring and Autumn Period, internal contradictions and conflicts emerged within various vassal states, a phenomenon common in powerful states like Jin, Chu, Lu, and Qi.

Although war community numbers changed, Jin, Chu, Zheng, Lu, Song, Wei, and Qi remained main war-initiating states and hegemonic powers throughout the Spring and Autumn Period. These war confrontation communities were geographically distributed, with neighboring states more prone to warfare (see Figure 7 [Figure 7: see original paper]). Major powers' invasions of surrounding small states didn't decrease due to hegemonic pattern changes; Jin, Chu, Qi, Lu, and other old states continued invading surrounding small states.

5 Maps of Spring and Autumn Period Wars

To more vividly and intuitively display wars in *Zuo Zhuan*, this study designed a dynamic HTML presentation of *Zuo Zhuan* wars on historical maps of the Spring and Autumn Period, allowing users to more directly understand various wars. First, ordinary Spring and Autumn Period maps were vectorized to give each state corresponding coordinate information. Then, E-Charts programs were written to load map data and war data between states for web display. Figure 8 [Figure 8: see original paper] shows the Battle of Dongmen in the fourth year of Duke Yin, with strategic offensive parties being Cai, Chen, Song, and Wei, and strategic defensive party being Zheng.

This study applies social network analysis to wars between vassal states during the Spring and Autumn Period described in *Zuo Zhuan*. On one hand, it extracts structured war cooperation and confrontation data from unstructured text; on the other hand, it quantitatively studies and visualizes this war data using social network analysis methods. During the structuring of *Zuo Zhuan* war data, the primary tasks were data summarization and organization, ensuring accuracy by combining previous research results with automatic computer extraction followed by manual verification. The first problem to solve when extracting war offensive and defensive parties from descriptive sentences was determining war direction based on war trigger words. Additionally, some sentences had unclear war parties, often using participating figures or war locations as substitutes, which were handled using directional processing of personal and place names with assistance from *Chunqiu Sanzhuan Yinde*. For sentences with

relatively complex syntactic structures, manual judgment was used to determine participating parties.

This paper provides a new interpretation of wars among various vassal states during the Spring and Autumn Period using digital humanities methods. On one hand, it provides a basis for interdisciplinary analysis (combining digital humanities and network science); on the other hand, it conducts empirical exploration and verification of some existing research results and controversies, expanding analytical approaches to Chinese historical issues and providing scientific references for historians. However, this study still has some limitations: the accuracy of using the Battle of Chengpu as a time point to divide the Spring and Autumn Period requires further exploration, and the accuracy of some research results needs verification.

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Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.