

VISUAL ANALYSIS FOR VOTING RELATIONSHIPS IN JOSEON DYNASTY, KOREA

Seongmin Mun^{1,2}, Gyeongcheol Choi², Sangkuk Lee³ and Kyungwon Lee⁴

¹UMR 7114 MoDyCo - CNRS, University Paris Nanterre, France

²Life Media Interdisciplinary Program, South Korea

³Department of History, South Korea

⁴Department of Digital Media, South Korea

ABSTRACT

History studies involve discovering new facts based upon the records as well as understanding relationships between historic events and figures. However, a vast amount of resources, background knowledge and time would be required for empirical historical research. *The Genealogy of the Kwon family* and *Annals of the Joseon Dynasty*, both of which are applied in this study, are particularly difficult to comprehend without sufficient knowledge about their terminologies and backgrounds. However, a vast amount of resources, background knowledge, and time would be required for empirical historical research. On the other hand, visual analysis enables users to easily understand information and the relationships between data. We propose an analysis method that visually describes voting relationships based on historical records, for a clear and cognitively beneficial understanding (URL: <http://202.30.24.167:3008/bubble>). Our visualization method is divided into two parts: First, it refines the database by selected options, such as by color and category. In the second part, users can confirm the details of this result with a bubble graph. These two parts are synchronized and describe the differences results based on the user's selection. In a case study of users' feedback and expert opinions, we verified the effectiveness and usability of our visualization method.

KEYWORDS

Visualization, Voting relationship, Bubble-graph, Historical data mining, Joseon-Dynasty

1. INTRODUCTION

Prior to being established as an individual academic discipline, historical studies was understood as a subset of other literature or interpreted from a religious perspective. Modern historical studies were established in the 1800s after German historian Leopold von Ranke argued that history is a study based on strict criticism of ancient records. History is thereby a discipline which empirically examines historical records in order to understand facts and the relationships between cause and effect. An empirical study is a method that identifies regularities and patterns through the objective analysis of historical records. As contemporary historical research methods are also based on empirical studies, precise understanding of time periods and objective attitudes toward research are considered essential. It remains difficult for researchers to stay objective during the entire study process, since understanding extensive historical records in order to precisely understand the exact time period requires a great deal of time and effort. Visualization analysis can thus enable users to better understand data by automatically analyzing accumulated data as well as offering a visual presentation. This analysis method can contribute to historical studies in the following ways. First, it shortens the time it takes to study historical records because of its automated method. Second, it improves the objectivity of studies through analysis based on mathematical algorithms. Third, visualized study results help users analyze and understand the results more effectively.

2. PURPOSE AND BACKGROUND

Current historical studies provide insufficient understanding of the link between present events and the past. "Modern" has been regarded as a conflicting concept from "Traditional," which has led to a binary perspective when attempting to understand the "traditional" (pre-modern) period. This phenomenon generally appears during events such as the confrontation between political powers in the late Goryeo to early Joseon dynasty (Hyungoo Min 1974), conflicts between the Meritorious Elite and Neo-Confucian Literati in the early Joseon dynasty (Soogeon Lee 1979), challenges in coterie politics in the late Joseon dynasty (Sogkjong Chong 1983; Seongmoo Lee 2000), and through confrontational understanding between colonized Koreans and Pro-Japanese Koreans during the Japanese colonial period (Dongmyung Kim 2006). However, since binary voting relationships in modern society share certain characteristics with those in the pre-modern period, they must be analyzed as an extension of voting relationships in pre-modern society. Therefore, we aim to discover the factors affecting binary voting relationships in the Joseon dynasty by analyzing historical records from the pre-modern period, annals of the Joseon Dynasty, and genealogy of the Kwon family; we also provide a visual representation of our findings.

3. RELATED WORK

Research to understand voting relationships through visualization, as well as integrated visualization studies are a growing trend. Adam Perer in CHI 2008, Francisco G. de Borja in SIBGRAPI 2015, Manjai Lee in Human Computer Interaction Korea and Hanmin Choi in Journal of Society of Design Convergence are ideal examples of previous research for our work.

Adam Perer analyzed the voting patterns of US senators with a network visualization tool, which was verified by political science experts in his article "Integrating Statistics and Visualization: Case Studies of Gaining Clarity" using exploratory data analysis. Figure 1 (a) illustrates the results of Perer's work.

Francisco G. de Borja studied the political history of Brazil by the visualization of political data in "CivisAnalysis: Interactive Visualization for Exploring Roll Call Data and Representatives' Voting Behaviour." He designed a visualization tool that gave citizens a unique view of the country's political history. Figure 1 (b) shows the results.

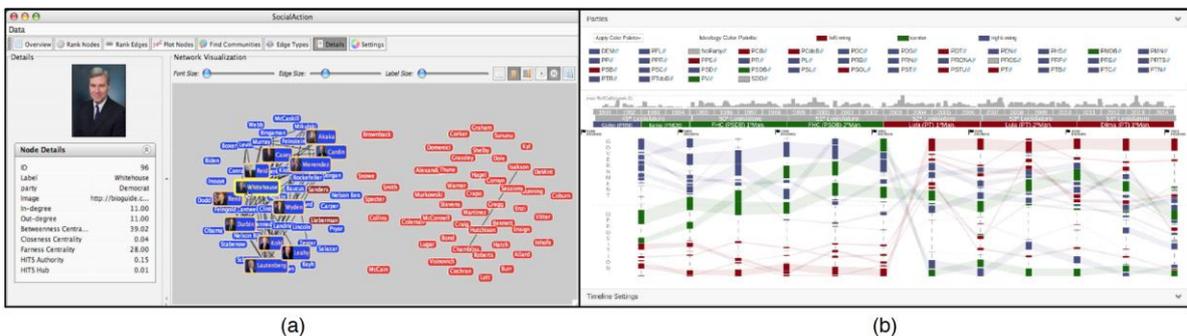


Figure 1. (a) Integration of statistics and visualizations by Adam Perer, (b) visual result by Francisco G. de Borja

Manjai Lee visualized UN voting record as public data to help everyone figure out the meaning of public data using proper visualization techniques. In his paper, to improve the weak point of the existing social graph visualization, he propose Friend-Matching, Friend-Rival Matching, and Bubble Heap algorithms in his paper. Figure 2 (a) shows the results.

Hanmin Choi proposed Interactive Visualization method that can be analyzed relations between nations in various viewpoints such as period, issue which is used total 5211 of the UN General Assembly voting data. He conducted a comparative experiment between Social Network Graph and Proximity based Circular Visualization. As a research result, he found that Proximity based Circular Visualization can be better to see analysis result by each node and Network Graph Visualization can be better to see analysis patterns for the nations. Figure 2 (b) suggests its results.



Figure 2. (a) Visualization of UN voting record by Manjai Lee, (b) interactive visualization by Hanmin Choi

4. USER TASKS AND DESIGN OBJECTIVES

We have refined voting relationship data with historians, linguists, and statisticians, focusing on a figure known as Geojeong Seo, including the historical agendas he supported and the voting results of these agendas. As he was a central figure who belonged to the power group in the Joseon Dynasty, we created data by assuming that individuals who were similar to Geojeong Seo belonged to a power group, while those showing few similarities would belong to a less powerful political group. Meanwhile, the Kwon family genealogy contains records of individuals related to Geojeong Seo by blood and their degree of consanguinity. This study explores a visual method to analyze voting relationships based on this data, and aims to discover factors affecting binary relationships between figures in the Joseon Dynasty. The tasks and visualization design objectives of our project are as follows.

Task 1: Calculating the similarity between each individual and Geojeong Seo for each agenda.

As we presumed that high similarities between an individual and Geojeong Seo would suggest that the individual also belonged to a power group, we calculated the similarities between the voting patterns of each individual utilizing a Phi coefficient and then visualized the results.

Design Objective: We should create an axis that indicates similarity levels in order to mark the relationships on it.

Task 2: Classifying agendas into specific categories to present voting relationships.

The total number of agendas in this research is 93, which includes different topics such as state affairs, royal family, diplomacy, politics, and customs. Based on our assumption that the nature of agendas would influence the relationships between individuals, we aim to visually represent these relationships in multiple ways, according to both overall and classified agendas.

Design Objective: Users should be able to select each classification that will illustrate different aspects of voting relationships according to each category.

Task 3: Presenting figures based on the degree of kinship.

Blood ties are highly likely to be a critical factor influencing the relationships between individuals. According to our hypothesis, blood relations will have a significant impact on the voting patterns of the characters. We visually explored voting relationships according to their kinship.

Design Objective: We need to visually distinguish relationships that involve blood relations from those that do not.

5. VISUALIZATION

To satisfy the three objectives described above, we followed Lee's(Lee & On, 2015) Bubble-heap graph design methodology in that only the X-axis is used to see the relationship between the central figure and the surrounding figures. A complete visualization, developed based on java script, can be found here <http://202.30.24.167:3008/bubble>. Through this visualization, we analyzed the voting tendency data of Joseon Dynasty, Korea by classified agendas and the effect of blood relations on voting tendency through color.

5.1 Phi coefficient

The agenda data in our research also contains personal opinions, which are represented as in favor (1), against (-1), and neutral (0). The phi coefficient, a measure of correlation used when two variables are divided by two quantitative categories, was applied in our study.

$$Phi\ coefficient = \frac{n_{11}n_{00} - n_{10}n_{01}}{\sqrt{n_1 * n_0 * n_0 * n_1}}$$

After calculating the relationships between individuals based on this formula, we provide a visual representation of the results. Figure 3 illustrates the relationships between the individuals calculated based on the overall agenda. The visualization we propose is shown in the x-axis. The individuals represented by each node are located along the axis, ranging from 0% to 100%.

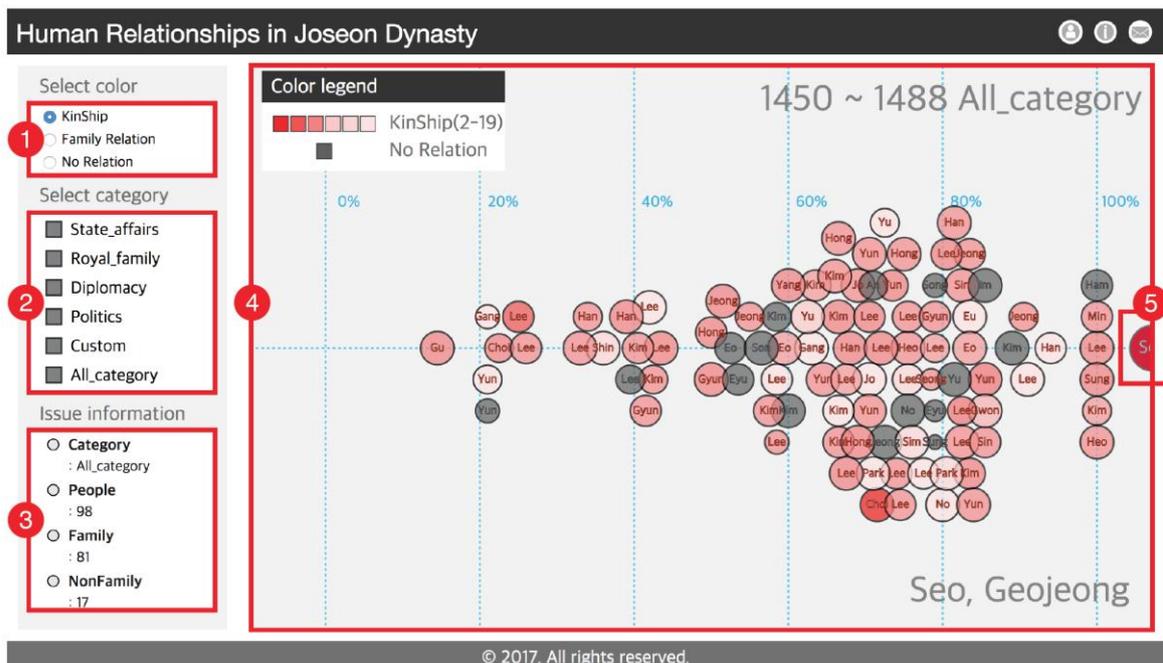


Figure 3. Voting relationships visualized based on the overall agenda

In the upper left area of visualization, there is a function to select different colors according to the relationship (blood, kinship). And you can select the category of the agenda in the middle (area 2). Also, in the bottom (area 3), we provide brief information by selected agenda. The main part of visualization (on the right side) shows the similarity by voting pattern between the central figure and the surrounding characters. Area 5, located in the right side of the main view, represents Geojeong Seo who was central figure in the Joseon Dynasty, Korea. If the voting tendency is completely consistent with Geojeong Seo, the figure located in line of 100%, or not in 0%.

5.2 Categorizing each issue

Agendas were classified as state affairs, royal family, diplomacy, politics, and customs, each of which was represented visually along with the overall agenda. We created a function to select each category in order to indicate changes in the relationship between individuals according to the nature of agendas. Figure 4 shows the relationship between individuals for each category, in the order of state affairs, royal family, diplomacy, politics, customs, and overall agenda.



Figure 4. Relationships between individuals and Geojeong Seo reflecting kinship

5.3 Family relationship

We have also assumed that kinship would be a significant factor in voting patterns. Individuals who were related to Geojeong Seo by blood are represented in red, as shown in figure 4. The color became darker if they were more closely related. Individuals who were not related to Geojeong Seo by blood are represented in gray.

6. EVALUATION

We conducted scenario and user studies to evaluate the effectiveness of our interactive visualization method and its usability. In the scenario studies, we worked with historians who studied the history of the Joseon Dynasty and possess expert knowledge about it. In the user study, we surveyed 22 people to evaluate our visualization method. The 22 people were either undergraduate students or professionals in data analysis who had a deep understanding of visualization and visual analysis.

6.1 Usage scenario for the visual analysis

We tested our visualization method based on three scenarios, drawing answers from our visualizations in order to find the solutions for each scenario.

- **Scenario 1: Is there a difference in voting patterns if the nature of agenda changes?**

Figure 4 shows the relationships between individuals for each category: state affairs, royal family, diplomacy, politics, and customs. This figure shows that politics and customs categories are leaning toward the right side, while the other categories show a relatively even distribution from 0% to 100%. Thus, we discovered that voting patterns varied according to categories of agenda, and that the patterns became more similar to Geojeong Seo with regard to politics and customs agendas.

● **Scenario 2: Will an individual show different voting patterns if the nature of agenda changes?**

According to historians, Myunghoi Han was another individual who was as prominent as Geojeong Seo by the time Seo was commissioned. After identifying the relationship between the two based on our visualization, we found out that voting patterns of Han varied according to each agenda category. Figure 5 shows changes in the similarity level between Myunghoi Han and Geojeong Seo, according to different agenda categories. While Han shared a high similarity level of over 70% with Seo on agendas relating to state affairs and politics, this decreased to less than 50% for agendas relating to the royal family, diplomacy, and customs. Furthermore, in the overall agenda, the similarity level bounced back to 60% -70%. These findings indicate that the voting patterns of an individual varied according to the nature of agendas, as Han deviated from Seo's agenda with regard to the royal family, diplomacy and customs, but showed higher similarities with Seo in state affairs and politics.

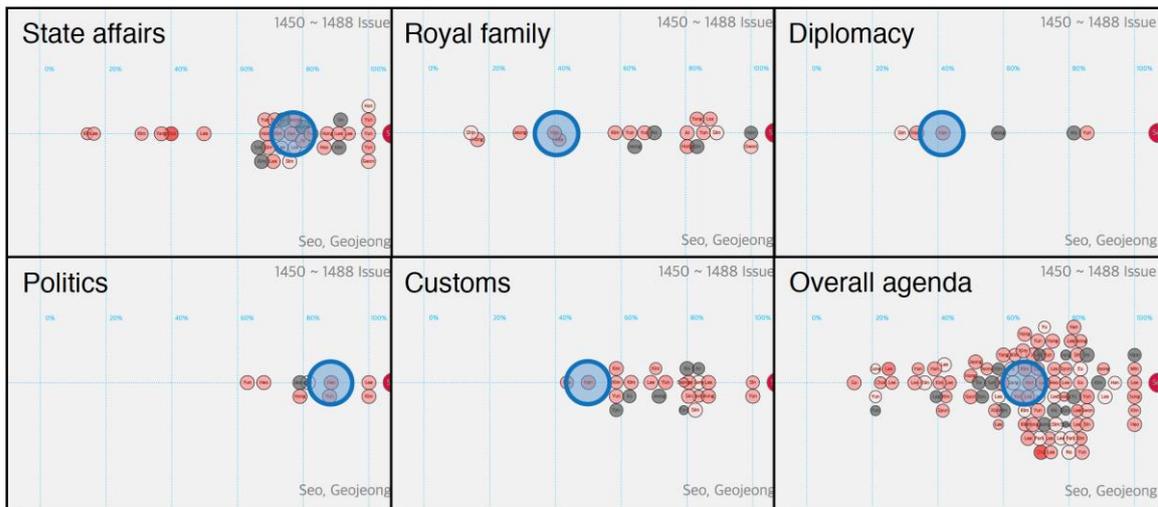


Figure 5. Similarity level changes between Myunghoi Han and Geojeong Seo, according to different agenda categories

● **Scenario 3: Will kinship affect the similarity level in voting patterns?**

The vast amount of previous studies suggests that blood relationships significantly influence voting relationships. We aimed to estimate the difference between individuals who were related to Seo by blood and those who were not, based on the same assumption. Figure 3 is a visualization of the overall agenda, which includes the largest number of relationships among the six visualizations. Each individual represented as a node is shown in red if they are related to Seo by blood and gray otherwise. We discovered that 81 out of the 98 people in our data were all related to Seo by blood, while the other 17 showed various distributions from 0 to 100. Thus, we could not determine whether kinship affected voting patterns in this particular case, and found that the majority of people who were commissioned at that time were related to Seo by blood.

6.2 User study

We performed an informal user study to evaluate our visualization method. We recruited 22 people, all of which have some experience in visualization. We first explained to them the basic concepts of our work and demonstrated the system functionalities. Then, we asked them to complete three exploration tasks with our system. Finally, we collected their feedback via a questionnaire and their opinions on the advantages and disadvantages of our system. Our questionnaire contained 13 questions in three categories: visual design, filtering, and system function. The answers are based on a five-level Likert Scale, where 1 means “Strongly Disagree,” 2 means “Disagree,” 3 means “Normal,” 4 means “Agree,” and 5 means “Strongly Agree.”

Table 1. Summary of the evaluation questions and results

Category		Questions	Rating
Visual design	Similarity	Q1: The similarity of the voting tendency between the central figure and surrounding characters is clearly shown through visualization.	4
		Q2: The blood relationship between the central figure and the surrounding characters is clearly shown through visualization.	4
		Q3: The kinship between the central figure and the surrounding characters is clearly shown through visualization.	3
	Issue	Q4: As the agenda changes, it can be confirmed that the voting tendency of the central character and other characters changed.	4
		Q5: It can be confirmed that the voting tendency of the characters is changed depending on the agenda selected.	4
	Color	Q6: It is easy to understand the blood relationship between characters through color.	4
		Q7: It is easy to understand the kinship of characters through color.	4
Filtering	Q8: It is easy to make changes by the agenda.	5	
	Q9: It is easy to make a color change.	4	
	Q10: Satisfied with the changed analysis results according to the selection.	4	
System	Q11: Data analysis results are easy to recognize in one view.	4	
	Q12: This visualization makes it easy to understand the voting patterns and blood relationships of the central figure and surrounding characters.	4	
	Q13: This visualization makes is easy to explore data analysis results.	4	

The results, summarized in Table 1, are very encouraging. For most questions, the median rating is above 4, which means that our system has fulfilled its design requirements and supports the major tasks. In particular, the only question with a rating 5 is Q8, which is about changing selection by agenda. During the free discussion, most users considered the functionality and interaction most satisfactory. One of them mentioned: "It's easy to understand the voting relationships between the central figure and surrounding characters." Another one said: "It is easy to make changes by agenda and color." On the other hand, the only question with a rating 3 is Q3, which is about showing kinship between the central figure and the surrounding characters. We need to improve the way to show kinship more easily.

7. CONCLUSION

The main significance of our research that it is an interdisciplinary study of historical studies, linguistics, statistics, and data visualization. Adopting a historical perspective that represents voting relationships as an extension of the past, we aimed to visually represent the relationships between individuals from past data and identify the factors affecting these relationships. We designed a visualization method in order to conduct this research and tested its effectiveness through three scenarios and a user study. The three key findings of this study can be summarized as follows.

First, the opinions on each five agenda will vary according to the nature of the agenda. Classifying the agendas in the Joseon Dynasty into state affairs, royal family, diplomacy, politics, and custom, the opinions regarding politics and customs showed a high similarity level of over 60%, and ranged from 0% to 100% in other the categories. Thus, it can be concluded that the nature of agendas influenced voting patterns.

Second, each figure individual indicated different opinions on different sets of agendas. As the nature of agendas influenced voting patterns, this can be used to discover the agendas that showed distinct gaps in opinions.

Third, blood relationships cannot be regarded as an integral factor that affects the similarity level of voting patterns. In one of our analyses, most of the individuals commissioned were related to Geojoeng Seo by blood. Although this implies that kinship itself is possibly a key factor for appointment to the state council, the relatively even distribution from 0% to 100% in our visualization suggests that kinship has no

significant impact on the similarity level of voting patterns. Figure 3 shows the relationships between each individual and Seo in terms of overall agendas. In addition, our work is unique in that it is an integrated research in historical studies, where empirical studies are of great importance. However, our findings should not be generalized since this was a cohort study focusing exclusively on the period when Geojeong Seo was commissioned to the state council. We thereby aim to expand the period covered in our future analysis.

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