

Innovative Visualization of Warfare in Peninsular Malaysia Using Cartographic Applications

Noor Suhaiza binti Sauti^{1*}, Noraishah binti Mustapa¹ & Noor Suhaizlin binti Sauti²

¹ Department of Civil Engineering, Politeknik Sultan Haji Ahmad Shah

² Department of Mechanical Engineering, Politeknik Kuching Sarawak

*suhaiza@polisas.edu.my

ABSTRACT: The visualization of historical conflicts plays a crucial role in preserving and understanding the past. This research examines the innovation of war visualization in Peninsular Malaysia through cartographic applications, focusing on three main objectives: identifying detailed historical information on significant conflicts; developing thematic maps using advanced cartographic techniques; and evaluating user acceptance of the resulting maps. A mixed-methods approach was employed for data collection, combining archival research and expert interviews. Historical records from national archives, libraries, and online repositories were analyzed, while semi-structured interviews with cartographers provided contextual insights. Cartographic Assisted Computer (CAC) systems and digital mapping tools, including ArcGIS, Paint.NET, and Canva, were utilized to create thematic maps. The analysis presents comprehensive data on major conflicts across various states in Peninsular Malaysia, detailing key events, locations, and historical figures. Thematic maps effectively illustrate the spatial and temporal dimensions of these conflicts, integrating detailed historical information. User evaluation involving historians, students, and lecturers (N=120), indicated high satisfaction with the clarity, informativeness, and usability of the maps. The findings highlight that cartographic visualization enhances historical understanding, offering an engaging and interactive approach to exploring the war history of Peninsular Malaysia.

Keywords: *Visualization, cartographic applications, thematic maps, historical*

1.0 INTRODUCTION

The study of historical conflicts is essential for preserving national heritage and fostering a deeper understanding of past events. Wars and conflicts shape the political, social, and cultural landscapes of nations, leaving a lasting impact on regional development and collective memory (Shah et al., 2018). Proper documentation and interpretation of these events are crucial for academic research and public education. However, traditional methods of presenting historical conflicts, which primarily rely on textual records such as official documents, letters, diaries, and newspapers, as well as static images, often fail to effectively convey the spatial and temporal aspects of these events (Hua & Chew Li Hua, 2016). While these sources provide valuable narratives, they can be dense and challenging to interpret, especially for individuals without a background in historical research. This limitation hinders a comprehensive understanding of how battles unfolded, where they occurred, and their broader implications.

In the context of Peninsular Malaysia, many significant historical conflicts remain underrepresented in interactive and visually engaging formats. Although historical records exist in archives, libraries, and online repositories, they are often fragmented and lack integration with modern cartographic tools. CAC software and digital mapping technologies offer new opportunities for visualizing historical events in a more engaging and accessible manner. These technologies allow for the transformation of textual records into interactive visual formats, making historical information more intuitive and accessible to a wider audience (Vancisin et al., 2020).

A thematic map is a sort of map that depicts a certain theme or subject area. Unlike standard reference maps, which depict a wide range of physical elements such as rivers, highways, and cities, thematic maps concentrate on specific data sets or topics. These maps utilize a variety of visual components, including colors, symbols, and lines, to show data on topics such as population density, climatic trends, economic activity, and historical events (Slocum et al., 2009). Thematic maps are useful tools for visualizing complex information in an understandable and accessible manner, making it easier to detect patterns, trends, and correlations within the data. Thematic maps, in particular, provide a structured way to represent complex historical data.

Despite the potential of cartographic visualization, research on its application in Malaysian historical studies remains limited. Existing visualizations often lack detail, interactivity, and accessibility, making it difficult for

students, researchers, and the general public to explore the complexities of historical conflicts (Reckziegel et al., 2021). Furthermore, the effectiveness of thematic maps in enhancing historical understanding has not been extensively assessed. The reliance on traditional text-based documentation restricts accessibility and engagement, particularly for educational and research purposes (Banerjee, 2024). Without an interactive approach, historical knowledge remains difficult to interpret and less engaging for modern audiences.

Digital cartography provides a novel solution to these challenges, enabling the creation of interactive thematic maps that visually represent historical conflicts with greater clarity. By integrating specialized tools used in the field of cartography to aid in the creation, analysis, and visualization of maps and advanced mapping tools, historical data can be presented in a way that enhances comprehension and engagement (Vancisin et al., 2020). However, the application of these techniques to historical conflicts in Peninsular Malaysia has not been thoroughly explored. Existing historical visualizations frequently lack comprehensive detail, limiting their effectiveness as educational and research tools. Additionally, the impact of cartographic visualization on user engagement and historical understanding has not been well evaluated.

This research aims to address these gaps by exploring the use of CAC and digital mapping tools in visualizing historical conflicts in Peninsular Malaysia. Specifically, the study focuses on three key objectives: identifying detailed historical information on significant conflicts, developing thematic maps using advanced cartographic techniques, and evaluating user acceptance of thematic maps. By integrating historical data with modern mapping technologies, this study seeks to enhance the accessibility and comprehension of Malaysia's war history, providing a more interactive and informative approach to historical education.

2.0 LITERATURE REVIEW

Historical conflicts have played a crucial role in shaping nations, influencing political boundaries, cultural identities, and societal structures. Effective documentation and visualization of these conflicts are essential for preserving historical knowledge and enhancing public awareness. Traditional methods, such as textual records, books, and archival documents, often present challenges in understanding complex historical events due to their static nature and lack of spatial representation (Shah et al., 2018). Recent studies highlight the growing need for innovative approaches, such as digital mapping and cartographic visualization, to improve the accessibility and comprehension of historical data (Reckziegel et al., 2021).

Cartographic visualization has emerged as a powerful tool for representing historical events in an interactive and spatially meaningful way. CAC software allow for the integration of historical data with geospatial elements, providing a dynamic approach to exploring conflicts (Vancisin et al., 2020). Thematic maps have been widely used to depict battlefield locations, troop movements, and war-related infrastructure, enabling users to grasp the geographic and temporal aspects of conflicts more intuitively (Scholz, 2024). Previous research demonstrates that cartographic-based historical maps enhance user engagement and foster deeper historical understanding by offering an immersive and interactive experience (Mogorovich & Salvatori, 2022).

The evolution of CAC and digital mapping tools has considerably enhanced the way historical data is displayed. Platforms like ArcGIS, QGIS, and Google Earth enable researchers to overlay historical maps with present geospatial data, providing insights into historical changes throughout time (Smith, 2024b). Furthermore, user-friendly digital tools such as Paint.NET and Canva have allowed non-experts to build theme maps that improve visual storytelling. According to studies, adopting CAC and Geographical Information system (GIS) into historical research not only enhances data representation but also allows for interdisciplinary partnerships among historians, geographers, and technologists (Gregory & Ell, 2014).

Despite its benefits, historical cartography confronts a number of problems, including data accuracy, historical interpretation biases, and technology constraints. Many historical records contain errors or insufficient information, making precise spatial representations difficult to achieve (Klehm, 2023). Furthermore, historical events are frequently open to different interpretations depending on political, cultural, or ideological perspectives. Ensuring the veracity and objectivity of thematic maps is still a major challenge in historical CAC research. Furthermore, the lack of interaction in some historical representations reduces user engagement and learning outcomes (Windhager et al., 2019).

The effectiveness of cartographic visualization in enhancing historical comprehension has been the subject of recent studies. Research on user engagement with CAC-based historical maps indicates that interactive and thematic maps significantly improve learning experiences by making complex information more digestible

(Smith, 2024a). User acceptance studies have shown that well-designed digital maps enhance clarity, usability, and overall historical awareness among students and researchers (Parellada & Carretero, 2022). However, there is a need for further research on how different user groups, including historians, educators, and the general public, perceive and interact with these visualizations.

While the CAC system and digital cartography have been widely used in worldwide historical studies, research on its application in Malaysian historical conflicts is sparse. Existing research on Malaysia's war history focus heavily on textual analysis, with little use of cartographic approaches (Abidin et al., 2018). The representation of important conflicts in Peninsular Malaysia, such as the Malayan Emergency and colonial resistance activities, has not received much attention in digital mapping efforts. This study aims to close this gap by creating CAC-based thematic maps of historical conflicts in Malaysia and assessing their efficacy in improving historical understanding.

The literature review highlights the importance of cartographic visualization in historical studies and its potential to improve the accessibility and comprehension of historical conflicts. While CAC and digital mapping tools have been widely used in global historical research, their application to Malaysian war history remains underdeveloped. Additionally, studies on user acceptance and engagement with thematic maps are still limited. This research aims to address these gaps by utilizing CAC and digital mapping tools to visualize historical conflicts in Peninsular Malaysia and assess their impact on historical comprehension and user engagement.

3.0 METHODOLOGY

This study employs a mixed-methods approach, combining qualitative and quantitative research methods to achieve a comprehensive understanding of the visualization of war events in Peninsular Malaysia using cartographic techniques. The research design includes archival research, digital mapping, and user evaluation.

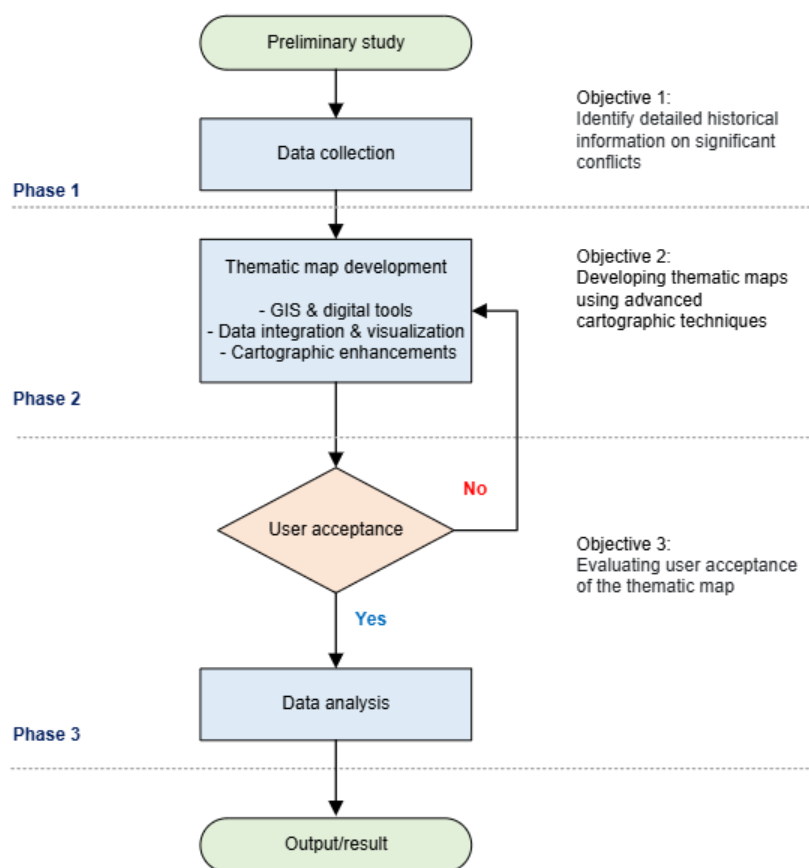


Figure 1: Research methodology

This research methodology comprises into three main phases: data collection, thematic map development, and user acceptance & data analysis (Figure 1). The methodology aims to develop a thematic mapping to visualize historical conflicts in Peninsular Malaysia using cartography tools while ensuring usability and effectiveness through user evaluations.

3.1 Data Collection

First phase focuses on collecting historical data on wars in Peninsular Malaysia. The goal is to collect accurate, precise, and geographically linked historical data that will serve as the foundation for creating thematic maps. This phase is separated into two major components: preliminary study and archival research and data collection. Prior to extensive data gathering, a preliminary study identifies research gaps and investigates how digital cartography can improve historical understanding. This includes evaluating the literature on historical conflict visualization, detecting gaps in traditional documentation, and investigating CAC system and digital maps. Research deficiencies include a lack of geographical representation for many historical conflicts in Peninsular Malaysia, as well as the non-interactive character of traditional methodologies. Data needs are specified, including the sorts of historical data required and cartographic features for user comprehension. Archival research then collects material from a variety of sources, including the National Archives of Malaysia, libraries, online repositories, and expert interviews, to ensure accuracy and comprehensiveness. The collected data contains geospatial data, historical information, and cartographic data for thematic maps.

3.2 Thematic map development

Phase 2 focuses on creating, developing, and refining theme maps for historical conflict visualization utilizing CAC system and digital tools, ensuring that historical data is translated into interactive and visually appealing maps. This step entails incorporating CAC system and digital tools for spatial analysis, data visualization, and cartographic upgrades, such as ArcGIS, Paint.NET, and Canva. Georeferencing historical war data involves mapping conflict sites as part of data integration and visualization. Cartographic elements are improved for use and readability by using color coding, symbols, labels, and legends. The first thematic maps are refined with expert evaluation and further updates to ensure accuracy, engagement, and effectiveness. By the end of this phase, fully developed thematic maps provide a thorough visual representation of historical conflicts in Peninsular Malaysia.

3.3 User acceptance and data analysis

Finally, third phase focuses on evaluating the effectiveness of CAC-based thematic maps and analyzing user responses to enhance historical understanding. This involves user acceptance evaluation and data analysis. The maps are tested for clarity, accessibility, and educational value with 120 respondents, including students and lecturers. Evaluation criteria include clarity, user engagement, and effectiveness in improving historical understanding. The process involves surveys, expert feedback, and map refinement based on user acceptance. Data analysis uses qualitative methods like thematic analysis of expert interviews and user comments, and quantitative methods like descriptive statistics and comparative analysis. The final output includes finalized maps, a research report, and recommendations for future research, ensuring the maps are user-friendly, accurate, and effective in improving historical understanding.

This methodology ensures a systematic approach to researching the role of cartographic visualization in the study of historical conflict. This study, which combines archival research, expert perspectives, cartographic mapping, and user evaluation, provides a complete framework for expanding the accessibility and engagement of Malaysia's war history through thematic cartography.

4.0 RESULTS AND DISCUSSIONS

The findings of this study illustrate the efficacy of applying cartographic technology to create historical war maps in Peninsular Malaysia. The findings are organized around the study's three objectives.

4.1 Identification of historical information

This research was able to obtain thorough historical information regarding important wars and conflicts in Peninsular Malaysia. significant Findings refer to historical records from national archives, libraries, and internet repositories that provide detailed information about war areas, significant figures, and events. Major conflicts and early colonial resistance warfare, have been identified and plotted. Details of the war have been determined based on their locations. Geospatial information was gathered and validated through expert conversations with historians and cartographers. This work enhances the availability and accessibility of historical conflict data by adding geospatial information.

4.2 Development of thematic maps using CAC and digital tools

The creation of thematic maps using CAC software (ArcGIS) and digital technologies is an important component of this research. A thematic map representing the historical battle was successfully constructed utilizing CAC system and digital cartography techniques (Figure 2). ArcGIS, Paint.NET, and Canva are used to create geospatial visualizations of historical events. Color coding, symbols, and interactive layers are all examples of cartographic innovations that dramatically improve map readability and engagement. This enhancement accurately depicts the site of the conflict. This approach has a significant impact since CAC-based thematic mapping converts textual historical records into an interactive and visually appealing manner, making historical data more intuitive and accessible.



Figure 2: Map of War in Peninsular Malaysia

4.3 Evaluation of user acceptance of thematic maps

This section will present the study's conclusions based on the data analysis of respondents' acceptance of the Peninsular Malaysia war-themed map, focusing on its usability, clarity, and informativeness. User acceptance was measured through a survey of 120 respondents, including 90 students and 30 lecturers, after they viewed and used the map. A Likert scale, with item ratings ranging from 1 to 5, was used for the score analysis (Saro et al., 2023). The Likert scale employed is shown in Table 3.1, and the interpretation of the mean score value ranges for thematic map acceptance is shown in Table 3.2.

Table 1
Likert Scale table

Scale	Level
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Table 2
Mean score values for Likert Scale levels of thematic map acceptance

Range of Means	Level
$1.00 \leq \text{mean} \leq 2.40$	Low
$2.41 \leq \text{mean} \leq 3.80$	Moderate
$3.81 \leq \text{mean} \leq 5.00$	High

The key findings from the survey revealed a generally high level of acceptance and satisfaction with the Peninsular Malaysia war-themed maps across various dimensions (Table 4.3). A high mean score of 4.33 for the thematic maps' clarity indicates that respondents thought the maps were understandable and straightforward, which is essential for effectively communicating historical information. With an informativeness score of 4.47, the maps improved users' comprehension of the war subject by offering pertinent and useful information. With a score of 4.20, the engagement level indicates that the maps were successful in capturing and maintaining respondents' attention, which is crucial for instructional materials. With an accessibility score of 4.21, the maps were usable by a variety of users, including those with varying degrees of subject-matter expertise (Jänicke, 2020).

Table 3
Evaluation of the thematic map acceptance

No.	Item	Mean Score	Level
1.	Clarity of thematic maps	4.33	High
2.	Informativeness of thematic maps	4.47	High
3.	Engagement level	4.20	High
4.	Accessibility	4.21	High
5.	Effectiveness in illustrating spatial dimensions	4.37	High
6.	Effectiveness in illustrating temporal dimensions	4.25	High
7.	Overall satisfaction with thematic maps	4.40	High
8.	Likelihood to recommend thematic maps	4.36	High
9.	Interactivity of thematic maps	4.20	High
10.	Innovative approach to exploring war history	4.59	High
	Total	4.34	High

The effectiveness in illustrating spatial dimensions received a high score of 4.37, indicating that the maps effectively conveyed geographical information, helping users understand the war's spatial aspects. Similarly, the effectiveness in illustrating temporal dimensions scored 4.25, suggesting that the maps were also effective in

conveying the timeline of events. The respondents gave the thematic maps an overall score of 4.40, indicating good satisfaction. The propensity to recommend the maps, which received a score of 4.36, revealed users' general acceptance of the maps and their belief that they were worthwhile enough to suggest to others. The interactive aspects of the maps, which received a 4.20 rating, enhanced user engagement and education. The respondents believed that the maps were a novel and practical way to study war history, as evidenced by the unique approach to studying military history having the highest score (4.59). This can be a significant way to differentiate the maps from other educational materials.

The total mean score of 4.34 suggests that thematic maps were highly appreciated. Even while all ratings are high, the somewhat lower engagement and interactivity scores (both 4.20) may indicate areas that should be improved. Improving these features may increase user efficacy and pleasure even further. The maps' unique value is underscored by their highest innovation score, implying that future innovation may maintain or even increase user satisfaction and interest. Overall, the results suggest that the themed maps are well-received and effectively serve their educational objectives.

5.0 CONCLUSIONS

This study explored the innovative use of cartographic techniques to visualize historical war events in Peninsular Malaysia. The study revealed that CAC systems and digital mapping significantly enhances knowledge and interaction with historical material. The thematic maps developed provided clear, intuitive, and interactive depictions of complicated historical events, making the material more accessible and entertaining to users. The findings of this study have significant implications for historical research and education. The use of cartographic visualization can transform the way historical events are studied and taught, providing a more interactive and engaging approach. This method can lead to new insights and a deeper understanding of historical events, making history more accessible to a broader audience. Future research could explore the application of cartographic techniques to other historical contexts and events. Additionally, further studies could investigate the integration of more advanced technologies, such as augmented reality and virtual reality, to enhance the visualization and interaction with historical data. Addressing the challenges and limitations identified in this study, such as data accuracy and technical complexity, will also be crucial for advancing this field.

REFERENCES

- Abidin, M. Z., Ibrahim, N., Muhammad, A., & Surat, M. (2018). The European Proceedings of Social & Behavioural Sciences. *Asia International Multidisciplinary Conference, August*, 551–562. <https://doi.org/http://dx.doi.org/10.15405/epsbs.2018.05.43>
- Banerjee, D. (2024). The Impact of Digital Tools on the Teaching of History: A Comparative Study of Traditional and Technology-Integrated Teaching Methods. *International Journal For Multidisciplinary Research*, 6(3), 1–5. <https://doi.org/10.36948/ijfmr.2024.v06i03.22919>
- Gregory, I. N., & Ell, P. S. (2014). Toward Spatial Humanities: Historical GIS and Spatial History. In *Historical GIS*. Indiana University Press. <https://doi.org/10.1017/cbo9780511493645.001>
- Hua, N., & Chew Li Hua, N. (2016). Legal Pluralism and Conflicts in Malaysia: The Challenge of Embracing Diversity. In *Religious Rules, State Law, and Normative Pluralism - A Comparative Overview* (Vol. 18, pp. 251–262). https://doi.org/10.1007/978-3-319-28335-7_15
- Jänicke, S. (2020). Teaching on the intersection of visualization and digital humanities. *VISIGRAPP 2020 - Proceedings of the 15th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*, 3, 100–109. <https://doi.org/10.5220/0008987101000109>
- Klehm, C. (2023). The Use and Challenges of Spatial Data in Archaeology. *Advances in Archaeological Practice*, 11(1), 104–110. <https://doi.org/10.1017/aap.2022.38>
- Mogorovich, P., & Salvatori, E. (2022). Historical GIS. In *Handbook of Digital Public History*. <https://doi.org/10.1515/9783110430295-037>
- Parellada, C., & Carretero, M. (2022). Digital Historical Maps in Classrooms. Challenges in History Education BT - History Education in the Digital Age. In M. Carretero, M. Cantabrana, & C. Parellada (Eds.), *History Education in the Digital Age* (pp. 143–161). Springer International Publishing. https://doi.org/10.1007/978-3-031-10743-6_8

- Reckziegel, M., Wrisley, D. J., Hixson, T. W., & Jänicke, S. (2021). Visual exploration of historical maps. *Digital Scholarship in the Humanities*, 36(May), II251–II272. <https://doi.org/10.1093/llc/fqaa059>
- Saro, J. M., Apat, J. Q., & Pareja, M. S. (2023). A Descriptive-Correlational Study of the Teachers' Motivation, Competences, and Perceptions in Writing Action Research. *Journal of Advances in Education and Philosophy*, 7(1), 14–24. <https://doi.org/10.36348/jaep.2023.v07i01.003>
- Scholz, L. (2024). The Atmosphere in Spatial History: Digital Evidence and Visual Argument*. *Past & Present*, December, gtae042. <https://doi.org/10.1093/pastj/gtae042>
- Shah, N. M., Rus, R. C., Mustapha, R., Hussain, M. A. M., & Wahab, N. A. (2018). The Orang Asli Profile in Peninsular Malaysia: Background & Challenges. *International Journal of Academic Research in Business and Social Sciences*, 8(7). <https://doi.org/10.6007/ijarbss/v8-i7/4563>
- Slocum, T. A., McMaster, R. B., Kessler, F. C., Howard, H. H., MacMaster, R., Kessler, F. C., & Howard, H. H. (2009). Thematic cartography and geovisualization, 3rd Edition. In *Thematic Cartography and Geovisualization, Fourth Edition*. <https://doi.org/10.1201/9781003150527>
- Smith, J. (2024a). 9 Approaches to Interactive Historical Maps That Reveal Lost Stories. Map Library. <https://www.maplibrary.org/1304/approaches-to-interactive-historical-maps/>
- Smith, J. (2024b). 9 Innovative Ways to Document Historical Changes on Maps That Reveal Time's Flow. Map Library. <https://www.maplibrary.org/1202/innovative-ways-to-document-historical-changes-on-maps/>
- Vancisin, T., Orr, M., & Hinrichs, U. (2020). Externalizing Transformations of Historical Documents: Opportunities for Provenance-Driven Visualization. *Proceedings - 2020 IEEE 5th Workshop on Visualization for the Digital Humanities, VIS4DH 2020*, 36–42. <https://doi.org/10.48550/arXiv.2009.02288>
- Windhager, F., Federico, P., Schreder, G., Glinka, K., Dork, M., Miksch, S., & Mayr, E. (2019). Visualization of Cultural Heritage Collection Data: State of the Art and Future Challenges. *IEEE Transactions on Visualization and Computer Graphics*, 25(6), 2311–2330. <https://doi.org/10.1109/TVCG.2018.2830759>