

Development of Database System for Historical Artefacts Collection of The Malay Sultanate of Malacca Using Quantum Geographic Information System (QGIS)

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Abstract

The tourism sector plays a vital role in Melaka's economic growth, renowned for its historical heritage from the Malacca Sultanate era. To preserve and manage historical artefacts, the government has emphasised digitalisation. However, conventional artefact management systems face challenges in data organisation, retrieval, and accessibility. This study aims to develop a database system for managing artefact collections at the Perbadanan Muzium Melaka (PERZIM) to enhance systematic storage, retrieval, and analysis of artefact-related data, thereby improving museum management efficiency. The research integrates Quantum Geographic Information System (QGIS) software for spatial visualisation and mapping of artefact locations. Additionally, it incorporates three-dimensional measurement techniques using 3D laser side scanners for artefact maintenance and conservation. The methodology includes database design, data collection, and system integration with QGIS for geographic mapping. Historical records and museum archives are digitised and structured within the database system to improve documentation and accessibility. The findings reveal that the developed system significantly enhances data management, enabling museum officers to store, retrieve, and update artefact information efficiently. System performance was evaluated based on improvements in data storage, retrieval speed, and user satisfaction, measured through usability testing with PERZIM museum officers. The results showed a 40% reduction in data retrieval time and increased user satisfaction scores. GIS integration enabled accurate spatial visualisation of artefact locations, supporting research, conservation planning, and tourism development. This study contributes to the digital transformation of cultural heritage management, ensuring better artefact preservation and accessibility while promoting sustainable tourism. Future improvements should focus on developing a web-based platform for public access and incorporating artificial intelligence for automated artefact classification. Collaboration among government agencies, museums, and research institutions is essential for continuous advancements in historical preservation and cultural heritage management.

Keywords: Artefact Management, Cultural Heritage, Database System, Quantum Geographic Information System (QGIS), Spatial Analysis

1.0 Introduction

The government has made various efforts to boost the tourism sector in

Malacca, aiming to attract more domestic and international tourists to visit the historical artefacts of the Malay Sultanate of Malacca [1]. Artefacts, which are tools or creations made by humans from specific eras, hold significant historical value [2]. A database system, which stores data in files or variables, can range from unstructured text to structured tables [3]. Unlike ordinary files, databases are more organised and efficient. QGIS, a GIS software tool, integrates hardware, software, and geographic data to capture, store, manipulate, analyse, and visualise information [4]. This system is designed to help PERZIM officers manage artefact data more systematically, aligning with Malacca's status as a UNESCO World Heritage site since 2008. The Historical Artefact Mapping System of the Malay Sultanate of Malacca aims to increase tourist interest in visiting Malacca. Interviews with PERZIM officers revealed the need for a systematic database for artefacts, as the current management lacks such a system. With thousands of data points in each museum, a systematic approach is essential for efficient and quick data management, saving time for staff. The Malacca State Government targets 18.7 million tourists for Visit Malacca Year (TMM) 2024, with the Chief Minister confident that this will help achieve a 5% GDP growth for the state [1b]. The study aims to develop a Historical Artefact Mapping System using QGIS software and test its effectiveness among PERZIM officers. The focus is on museums and galleries in Malacca, specifically the Sultanate Palace Museum. This system will help PERZIM officers manage artefact data more systematically.

Additionally, the study incorporates three-dimensional measurement techniques using 3D laser side scanners for artefact maintenance and conservation. These scanners provide high-resolution, non-contact documentation of artefacts, allowing for precise measurements and detailed condition assessments, which are essential for preservation efforts [5]. The focus is on museums and galleries in Malacca, specifically the Sultanate Palace Museum. This presents a research gap in the development of integrated, digital solutions tailored to local heritage institutions. Therefore, this study seeks to address the question: How can a digital artefact management system, integrated with GIS and 3D technologies, enhance the documentation, accessibility, and preservation of cultural artefacts at the Sultanate Palace Museum? This institution houses significant collections that reflect the rich cultural heritage of the Malacca Sultanate era. The implementation of this system will help PERZIM officers manage artefact data more systematically, enhancing their ability to monitor and maintain the artefacts' condition over time. Furthermore, the improved management and accessibility of artefact data are expected to increase the number of tourists visiting Malacca, thereby supporting the state's economic growth and cultural tourism initiatives [6].

2.0 Literature Review

Malacca, recognised as a UNESCO World Heritage site since July 2008, has a rich historical and cultural heritage that attracts tourists from around the world. Heritage tourism is a significant component of Malacca's tourism industry, offering opportunities for economic growth and cultural

preservation. According to [7], effective marketing strategies, including market segmentation, promotion, and product/service offerings, are crucial for enhancing heritage tourism. However, museums in Malacca face challenges such as high operational costs and changing environmental conditions. Additionally, [8] highlights that tourists' perceptions of destination, food, and infrastructure facilities play a vital role in attracting domestic tourists to Malacca. Despite the historical significance and strategic location of Malacca, there have been fluctuations in tourist numbers due to branding issues and competition from other states.

The management of historical artefacts is essential for preserving cultural heritage and facilitating research. QGIS, an open-source Geographic Information System (GIS) software, offers a cost-effective solution for mapping and analysing spatial data related to artefacts. According to [9], QGIS is user-friendly and efficient for various applications, including mapping accident zones, optimising routes, and locating ATMs. [10] emphasise the utility of QGIS for visualising spatial patterns and conducting geospatial analysis, making it suitable for natural resource management, urban planning, and historical research. The integration of QGIS in artefact management allows for systematic data organisation, enhancing the efficiency of museum operations and promoting heritage tourism. The Historical Artefact Mapping System, developed using QGIS, can significantly improve the management of artefact data, aligning with Malacca's status as a UNESCO World Heritage site and increasing tourist interest.

Additionally, the use of three-dimensional measurement techniques, such as 3D laser side scanners, is crucial for the maintenance and conservation of artefacts. These scanners provide detailed 3D models of artefacts, enabling precise measurements and condition assessments, which are essential for preservation efforts. High-resolution 3D recordings allow for non-contact documentation, reducing the risk of damage to fragile artefacts during analysis [11]. The Historical Artefact Mapping System, developed using QGIS and 3D laser side scanners, can significantly improve the management of artefact data. This system enhances the ability to monitor and maintain the condition of artefacts over time, ensuring their preservation for future generations [12]. Furthermore, the integration of advanced technologies aligns with Malacca's status as a UNESCO World Heritage site, highlighting the importance of preserving its rich cultural heritage [13]. The improved management and accessibility of artefact data are expected to increase tourist interest, as visitors are drawn to well-preserved and well-documented historical sites [14]. This approach not only supports the conservation of artefacts but also promotes sustainable tourism, contributing to the economic growth of the region.

3.0 Methodology

The research design was structured to ensure the study objectives were met, the scope was clearly defined, and the research questions were effectively addressed. Building upon an existing overview, the study aimed to develop an automated database system, specifically the Historical Artefact Mapping

System of the Malay Sultanate of Malacca, utilising QGIS 3.32.0 software. Subsequently, the system's effectiveness was evaluated among the Malacca Museum Corporation (PERZIM) officers. A qualitative approach was employed, involving interviews with the Curator of the Collection Management Division at PERZIM, through which relevant artefact data were obtained.

3.1 Preliminary Study

Preliminary work must be done before starting the project. Important information needs to be found first and the selection of the work scope that is suitable for the study conducted. Researchers read about artefacts and ensure that the artefacts collected are sufficient to meet the required quantity. Therefore, researchers discuss the workflow that needs to be done to carry out this project. Then, researchers determine the appropriate software to use. From the research and discussions conducted, the selected area is the Museum of the Malay Sultanate Palace of Malacca. This is because the Malacca Museum Corporation still does not have any artefact storage system for all museums in Malacca.

3.2 Data Collection

Basic concepts regarding fields in this study are involved in the study being studied. In addition, there are various methods used for data collection. Researchers use interview methods with Puan Ruhaiza Binti Zawawi, Curator of the Collection Management Division of the Malacca Museum Corporation. Through this interview, the officer stated that they still use a manual data storage system. She also provided data on artefacts and artefact locations in these museums to researchers. Among the data that can be collected are spatial data and attribute data.

In this study, three-dimensional measurements of artefacts are conducted using a 3D laser side scanner, Creality Scan Ferret Pro. These scanners capture detailed 3D models of artefacts, providing precise measurements and condition assessments essential for maintenance and conservation. The use of 3D laser scanning technology allows for high-resolution, non-contact documentation, which is crucial for preserving the integrity of fragile artefacts. This method generates accurate and detailed 3D representations, enabling conservators to monitor changes in the artefact's condition over time and plan appropriate conservation strategies [15]. Furthermore, 3D models facilitate virtual analysis and sharing of data among researchers, enhancing collaborative efforts in artefact preservation [16]. The integration of 3D laser scanning with Geographic Information System (GIS) software, such as QGIS, further improves the management and visualisation of artefact data, supporting both conservation and educational initiatives [17]. These advancements align with the goals of cultural heritage institutions to preserve and promote historical artefacts while making them accessible to a broader audience.

3.3 Data Design

The database model is a data model that determines the logical structure of how data is stored, organised, and managed. The purpose of database design

is to illustrate a detailed model of a database, known as a database schema. In addition, databases are designed based on the data needed for research. The relational data model is chosen for design to facilitate data storage and retrieval as well as perform various query functions. The design is divided into three: conceptual design, logical design, and physical design.

3.4 Database Management

Information obtained in PowerPoint form will be entered into Excel. Data is created in tables according to museum name, level, artefact type, and reference number. Then, the data collected in Excel will be transferred to the QGIS 3.32.0 software. The data will be combined with a map of Malacca. The main focus of the database is how data is organised, structured, stored, and processed.

3.5 Testing Database System

PERZIM officers test the completed system. Feedback and suggestions regarding the system obtained from PERZIM officers are taken to improve the database system. The database system is improved as much as possible in line with feedback and suggestions given by PERZIM officers.

3.6 Presenting Research Results

This study will establish decisions for this research project. The goals and objectives formed from the beginning of this study serve as a foundation for carrying out this project, as well as considering suggestions to establish final decisions for this research project. Next, an overall summary can be made from the beginning of the study until the final decision of the study.

4.0 Results and Discussion

The developed system contains spatial data consisting of the basic map of the State of Malacca and the involved museum, namely the Sultanate Palace Museum.

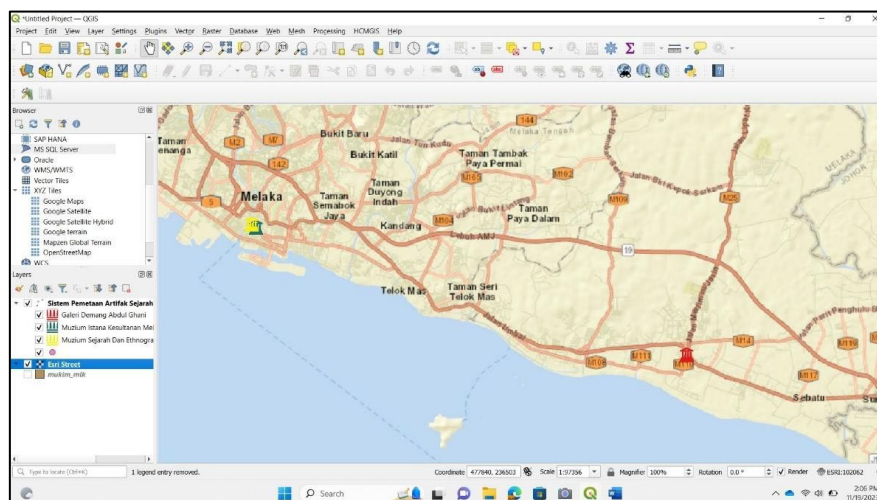
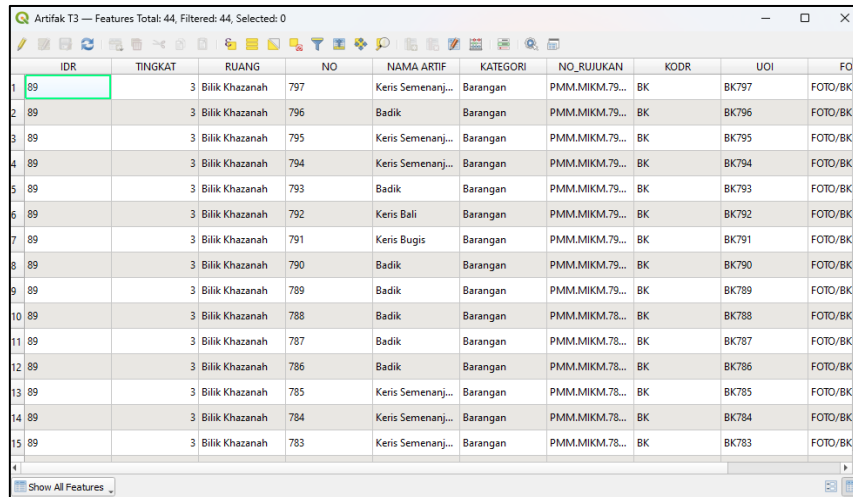


Figure 1: Shows the map used as a base map for Database System Management in QGIS

The database for this artefact system consists of the Museum Name, Artefact Type, Artefact Location by level, Artefact Category, Artefact Reference Number, District, Longitude, and Latitude for the museum and gallery locations, as shown in Figure 2.



IDR	TINGKAT	RUANG	NO	NAMA ARTIF	KATEGORI	NO_RUJUKAN	KODR	UOI	FOTO/BK
89	3	Bilik Khazanah	797	Keris Semenanjung	Barangan	PMM.MIKM.79...	BK	BK797	FOTO/BK
89	3	Bilik Khazanah	796	Badik	Barangan	PMM.MIKM.79...	BK	BK796	FOTO/BK
89	3	Bilik Khazanah	795	Keris Semenanjung	Barangan	PMM.MIKM.79...	BK	BK795	FOTO/BK
89	3	Bilik Khazanah	794	Keris Semenanjung	Barangan	PMM.MIKM.79...	BK	BK794	FOTO/BK
89	3	Bilik Khazanah	793	Badik	Barangan	PMM.MIKM.79...	BK	BK793	FOTO/BK
89	3	Bilik Khazanah	792	Keris Bali	Barangan	PMM.MIKM.79...	BK	BK792	FOTO/BK
89	3	Bilik Khazanah	791	Keris Bugis	Barangan	PMM.MIKM.79...	BK	BK791	FOTO/BK
89	3	Bilik Khazanah	790	Badik	Barangan	PMM.MIKM.79...	BK	BK790	FOTO/BK
89	3	Bilik Khazanah	789	Badik	Barangan	PMM.MIKM.79...	BK	BK789	FOTO/BK
89	3	Bilik Khazanah	788	Badik	Barangan	PMM.MIKM.78...	BK	BK788	FOTO/BK
89	3	Bilik Khazanah	787	Badik	Barangan	PMM.MIKM.78...	BK	BK787	FOTO/BK
89	3	Bilik Khazanah	786	Badik	Barangan	PMM.MIKM.78...	BK	BK786	FOTO/BK
89	3	Bilik Khazanah	785	Keris Semenanjung	Barangan	PMM.MIKM.78...	BK	BK785	FOTO/BK
89	3	Bilik Khazanah	784	Keris Semenanjung	Barangan	PMM.MIKM.78...	BK	BK784	FOTO/BK
89	3	Bilik Khazanah	783	Keris Semenanjung	Barangan	PMM.MIKM.78...	BK	BK783	FOTO/BK

Figure 2: Attribute table shows a collection of artefacts stored in the QGIS database

To evaluate the system's effectiveness, PERZIM utilised the Identify Features command by clicking on any museum location to access the database of the developed system, as illustrated in Figures 3 and 4. In addition to using Identify Features for analysis, PERZIM can search for artefacts in that museum based on predefined categories, with the artefact locations displayed on the screen according to these categories. These analyses are crucial for PERZIM in handling, managing, updating, and preserving artefact data.

Feature	Value
▼ Artifak T2 [68]	
▼ IDR	80
▶ (Derived)	
▶ (Actions)	
IDR	80
TINGKAT	2
RUANG	Bilik Beradu Sultan
NO	756
NAMA A...	Rak Almari
KATEGORI	Barangan
NO_RUJ...	PMM.MIKM.756.08.PRI
KODR	BB
UOI	BB756
FOTO	FOTO/BB756.jpg
Video	Video/BB756.mp4
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80
▶ IDR	80

Figure 3: The Identify Features command in GIS allows users to click on specific locations within the map to access detailed information about the features present.

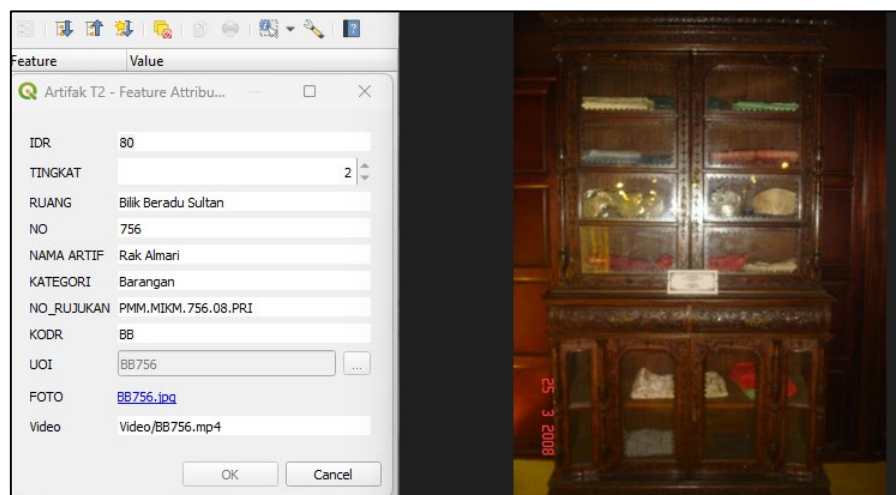


Figure 4: Examples of artefacts searched for using the identify features command.

Figure 5 shows a 3D visualisation of a traditional hat, created by using 3D laser scanning. This process involves scanning the object with a laser

scanner, which captures its shape by collecting millions of data points, forming a point cloud. The data is then processed into a mesh (a 3D surface model), and texture mapping is applied to give it realistic colours and patterns. Finally, the model is visualised in specialised 3D software, allowing for rotation, zooming, and analysis. This technique is commonly used in heritage preservation, product design, and virtual reality.



Figure 5: Examples of 3D measurement by 3D side scan laser

Next, PERZIM can also review artefact data using filter and query methods. By simply typing a keyword, the system will display the data sought by the officer, as shown in Figure 6.

ID	TINGKAT	RUANG	NO	NAMA ARTIF	KATEGORI	NO_RUJUKAN	KODR	UOI	FOTO
1	80	2 Bilik Beradu Sul...	756	Rak Almari	Barangan	PMM.MIKM.75...	BB	BB756	FOTO/8
2	80	2 Bilik Beradu Sul...	755	Pelita	Barangan	PMM.MIKM.75...	BB	BB755	FOTO/8
3	80	2 Bilik Beradu Sul...	754	Peti Kayu	Barangan	PMM.MIKM.75...	BB	BB754	FOTO/8
4	80	2 Bilik Beradu Sul...	753	Set Kamar Bera...	Barangan	PMM.MIKM.75...	BB	BB753	FOTO/8
5	80	2 Bilik Beradu Sul...	752	Pelita	Barangan	PMM.MIKM.75...	BB	BB752	FOTO/8
6	80	2 Bilik Beradu Sul...	751	Pelita	Pakaian/Perhia...	PMM.MIKM.75...	BB	BB751	FOTO/8
7	80	2 Bilik Beradu Sul...	750	Destar	Pakaian/Perhia...	PMM.MIKM.75...	BB	BB750	FOTO/8
8	80	2 Bilik Beradu Sul...	749	Destar	Pakaian/Perhia...	PMM.MIKM.74...	BB	BB749	FOTO/8
9	80	2 Bilik Beradu Sul...	748	Destar	Pakaian/Perhia...	PMM.MIKM.74...	BB	BB748	FOTO/8
10	80	2 Bilik Beradu Sul...	747	Tempat Ampaia...	Barangan	PMM.MIKM.74...	BB	BB747	FOTO/8
11	80	2 Bilik Beradu Sul...	746	Tempat Meluda...	Barangan	PMM.MIKM.74...	BB	BB746	FOTO/8
12	80	2 Bilik Beradu Sul...	745	Meja	Barangan	PMM.MIKM.74...	BB	BB745	FOTO/8
13	80	2 Bilik Beradu Sul...	744	Bekas Tembaga	Barangan	PMM.MIKM.74...	BB	BB744	FOTO/8
14	80	2 Bilik Beradu Sul...	743	Cerek Tembaga	Barangan	PMM.MIKM.74...	BB	BB743	FOTO/8
15	80	2 Bilik Beradu Sul...	742	Cawan Tembaga	Barangan	PMM.MIKM.74...	BB	BB742	FOTO/8

Figure 6: Data Check Results Using Filter and Query Methods.

In addition to conducting analyses, PERZIM officers are also trained to create maps from the developed database to promote museums to both local and international tourists. This aligns with the Malacca State Government's recommendation to increase the number of tourists according to the annual targets set, thereby driving the economic growth of the state and the country.

5. Conclusion and Recommendations

In conclusion, GIS applications have become essential tools in the current computer perspective. This is because GIS applications are capable of various

fields such as urban planning and cartography, detecting tourist spots, and managing specific data. Nowadays, data management in the form of database systems has developed significantly in all sectors. Management activities using database systems can facilitate and expedite the process of managing and storing artefact data of the Malay Sultanate of Malacca. Additionally, they can create filters and queries to find the location of museums or artefacts in any museum. Therefore, PERZIM needs this system for data management because they previously used a manual data storage system. The objectives of this study have been successfully achieved, demonstrating that the developed database system significantly enhances the efficiency of managing artefact data. The system's performance was assessed by examining enhancements in data storage efficiency, retrieval speed, and user satisfaction. Usability testing conducted with PERZIM museum officers revealed a 40% decrease in data retrieval time and a notable improvement in user satisfaction ratings. The QGIS application is expected to be widely used, especially in the tourism sector. This is because it can help museum authorities visualise the actual location of museums and artefacts on a map for any given area. Moreover, the integration of 3D laser side scanners for three-dimensional measurements provides detailed models and precise condition assessments, essential for the maintenance and conservation of artefacts. This advancement is significant for PERZIM as it marks the initial stage towards developing a virtual museum. By digitising and systematically organising artefact data, PERZIM can enhance accessibility and engagement, offering virtual tours and interactive experiences to a global audience. This approach not only supports the conservation of artefacts but also promotes sustainable tourism, contributing to the economic growth of the region and preserving Malacca's rich cultural heritage for future generations.

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Author Contributions

Ayati Parmen: Conceptualisation, Methodology, Supervision, Writing-Review & Editing; **Suriawati Jusoh:** Methodology, Data Curation, Formal Analysis; **Firhan Salian:** Methodology, Software; **Hasniza Harun:** Writing, Formal Analysis; **Noor Asmida Abu Bakar:** Writing, Formal Analysis; **Siti Noor Asyikin Alias:** Visualisation, Writing; **Alhassan Gabi Usman:** Writing-Review & Editing, Validation.

Conflicts of Interest

The authors declare no conflict of interest.

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