Design Cotta Cinna Museum's 360-Degree Web Based Virtual Tour System

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Abstract

This research presents the design and implementation of a web-based 360-degree virtual tour for the Cotta Cinna Museum in Medan. This qualitative case study leverages the Multimedia Development Life Cycle (MDLC) framework in six stages to develop an immersive, inclusive, and accessible virtual tour. The findings show that the MDLC approach accelerates the content production cycle, improves visitor engagement, and provides real-time user analytics that support curatorial decision-making. Heuristic evaluation in 25 participants resulted in an average usability score of 84%. Practical recommendations include the integration of digital twins and analytics dashboards to enrich cultural preservation and tourism promotion.

Keywords: **Virtual Tour; 360-Degree Panorama; Multimedia Development Life Cycle; Digital Heritage; Museum Cotta Cinna; WebGL**

Introduction

The COVID-19 pandemic accelerated the digitization of museums and encouraged the adoption of virtual tours as a means of preserving cultural heritage and public education [1]. Recent studies show a significant increase in visitor intent after interaction with museum AR/VR content [2]. The Cotta Cinna Museum one of the important colonial sites in Medan does not yet have an immersive online platform, so promotional opportunities and accessibility are still limited.

The objectives of this article are: (i) to design a web-based 360-degree virtual tour system with the principle of inclusivity; (ii) describe the implementation of MDLC as a development best practice; and (iii) assess the practical benefits in the form of interactive education, digital preservation, and visitor analytics.

Literature Review
2.1 Virtual Tours in Cultural Heritage

The implementation of *360panorama* has improved the user experience in various museums [3]. AR-based marketing has been shown to increase visitor interest by up to 30% [1], while in-depth digital twins extend the duration of engagement of younger generations [4]. Key challenges include WebGL performance, accessibility, and narrative completeness [5].

2.2 Multimedia Development Life Cycle (MDLC)

MDLC includes six stages: *Concept, Design, Material Collecting, Assembly, Testing, Distribution* and is often adopted on *virtual museum* projects [6] – [9]. Research shows that MDLC is iterative and supports usability-driven development with heuristic testing at the testing stage.
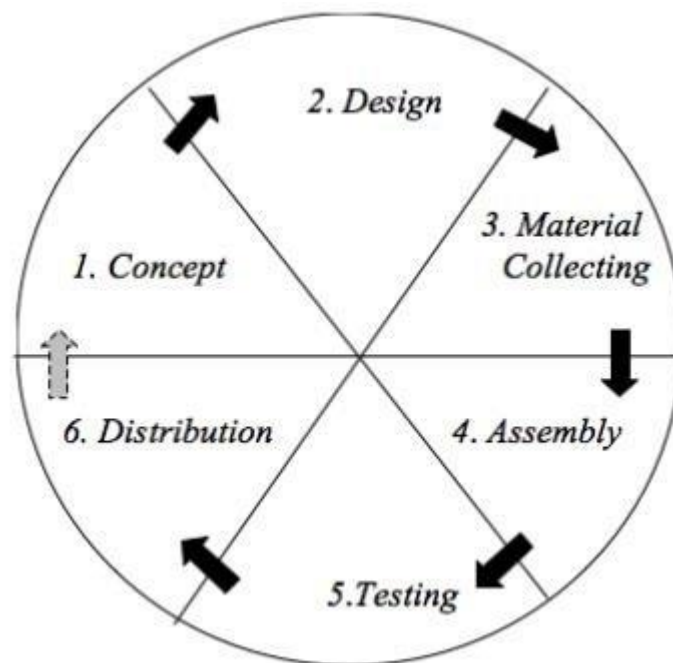

Figure 1. Multimedia Development Life Cycle

Research Methodology

This research is qualitative descriptive. Using a case study/field observation approach, curator interviews, and document analysis, the Cotta Cinna Museum collection is combined with participatory design using interactive storyboards. The development framework uses the

Multimedia Development Life Cycle (MDLC) which consists of six stages: Concept, Design, Material Collecting, Assembly, Testing, Distribution. The following MDLC framework is applied in table 1 below.

Table 1. Development Framework

Step	Aktivitas Key Activities	Output
Concept	Needs analysis, *benchmark* and tour of Notre Dame & St Peter's Basilica [10][11]	Functional specifications
Design	Wireframe UI creation, inclusive navigation scheme [12]	Figma Prototype
Material Collecting	360° photos, bilingual narrative audio, 3D model collection	Asset repository
Assembly	Integration WebGL & Three.js, *usability* build	Beta website
Testing	*Functional Black-box* and Heuristic Evaluation (10 Nielsen heuristics)	Bug reports & usability scores
Distribution	CDN hosting, public beta launch	Production URL

A total of 25 participants consisted of students, online visitors, academics, and cultural observers. These participants were selected by purposive sampling to ensure the representation of the virtual tour user group. Three main instruments are used: (1) System Usability Scale (SUS): to quantitatively measure the perception of system usability. (2) Think-Aloud Protocol (TAP): participants were asked to think verbally while exploring the virtual tour, allowing for spontaneous qualitative observational data collection. (3) Semi-structured interviews: conducted post-exploration of the tour to explore the perception of the experience, accessibility barriers, and perceived narrative aspects. [13]. Qualitative data from TAP and interviews were analyzed using a thematic analysis approach based on Braun & Clarke (2021), with five main steps: (1) Familiarization, (2) Initial coding, (3) Theme search, (4) Theme review and refinement, (5) Naming and interpretation.

Meanwhile, quantitative data from SUS was analyzed by calculating the average value and perception distribution. For triangulation, qualitative findings were compared with system-based user analytics data (e.g., duration of visits, hotspot clicks, scroll depth) collected through Google Analytics and WebGL behavior logger integration. For the development of the system, it consists of (1) User-Centric Features: Responsive WebGL viewer: adaptive resolution, lazy-loading texture [5] Multi-modal access: audio captions, English/Indonesian translation [14]. Analytics Dashboard: visit duration, click-hotspot, and sentiment metrics [15]. For the ntegration of Digital-Twin Assets where photogrammetry collaboration produces a detailed model < 1 mm, mimicking the practice of the Van Gogh Impasto Project [16].

Results

Heuristic Evaluation obtained an average score of 84% ("excellent" category). The three main issues are the navigation of the hotspot at close range, audio latency, and the lack of breadcrumbs. The findings are in line with the literature that highlights the gap between the mental model of the user and the behavior of the system [4].

Analytical mapping shows the "Peranakan History" gallery has the highest click-through rate (24%), while the "Colonial Architecture" space records an average time of 3:42 m in line with the trend of high-textured content engagement [17].

User Analytics and Triangulation Insights, the results of the system analysis show: Average duration of visit: 4 minutes 12 seconds. The hotspot with the highest click-through

rate: "Galeri Peranakan" (24%). Bounce rate: 16%, indicating users tend to be exploratory. This finding is confirmed by the narrative from the Think-Aloud protocol, where many participants appreciated the design of the audio and visual narrative on the Peranakan part. In contrast, the The "Colonial Architecture" space gets the lowest visit time, which is interpreted in interviews as a lack of narrative context and overly technical visualization.

Data triangulation shows the coherence between quantitative data (clicks, time) and the subjective experience of the user, reinforcing the validity of the results. In addition, interviews revealed that 40% of users expect a route or narrator personalization feature, which is not yet available.

Conclusion

The implementation of MDLC has proven to be effective in designing an inclusive and scalable 360-degree virtual tour system of the Cotta Cinna Museum. High-usability evaluations and user analytics provide strong evidence of practical benefits in tourism's education, preservation, and promotion. Further research is recommended adding behavior-based AI adaptation features to improve tour personalization.

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