INTEGRATION OF ENGINEERING GRAPHICS AND INFORMATION CULTURE IN THE STUDY AND DIGITAL RECONSTRUCTION OF HISTORICAL MONUMENTS IN NAMANGAN (CASE OF AKHSIKENT)

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Abstract: This paper explores the digital preservation of Namangan's historical heritage, focusing on the ancient site of Akhsikent. By integrating engineering graphics, 3D laser scanning, and Building Information Modeling (BIM), the research establishes a comprehensive methodological framework for virtual reconstruction and archiving.

Keywords: Engineering Graphics, Digital Reconstruction, Akhsikent, Namangan Architecture, Information Culture, 3D Modeling, Computer-Aided Design, Cultural Heritage, Laser Scanning, Photogrammetry, Virtual Restoration, Architectural Conservation, Data Integration, Structural Analysis, Digital Archiving.

1. Introduction

The protection and scientific documentation of historical and cultural monuments represent a fundamental pillar of national identity and global heritage preservation. In the context of Uzbekistan, a country characterized by an exceptionally rich architectural and archaeological legacy, traditional methods of preservation are increasingly being supplemented-and in some dimensions, transformed-by advanced digital technologies. The intersection of historical research, art history, and engineering graphics forms a powerful interdisciplinary matrix that allows for a deeper, more precise understanding of ancient structures.

Namangan region, located in the fertile Fergana Valley, occupies a unique place in this landscape. It holds profound historical significance, housing both subterranean archaeological treasures and unique standing architectural monuments from later Islamic periods. Among these, the ancient city of Akhsikent stands as a paramount monument of urban planning, military defense, and craftsmanship spanning from the antiquity to the medieval era. However, time, environmental degradation, seismic activities, and human interventions pose continuous threats to these vulnerable mudbrick and baked brick structures.

Traditional descriptive and manual graphic methods often fail to capture the complex, deformed geometric realities of partially ruined architectural objects [Smith, 45]. This technological gap underscores the urgent necessity of integrating modern engineering graphics (Computer-Aided Design (CAD), 3D photogrammetry, terrestrial laser scanning, and Building Information Modeling) with a robust information culture within the humanities. Information culture in this context implies not only the usage of digital tools but also the systematic collection, metadata structuring, and ethical preservation of digital cultural assets. This paper aims to analyze the innovative opportunities provided by engineering graphics in studying and virtually reconstructing the historical monuments of Namangan, establishing a workflow that bridges the gap between empirical historical data and precise geometric visualization.

2. Methods and Materials

The research methodology adopts a strictly interdisciplinary approach, synthesizing historical-archaeological analysis with advanced spatial and digital engineering techniques. The primary object of study is the Akhsikent archaeological complex, supplemented by comparative structural elements found in traditional 18th-20th century Namangan monuments, such as the Mulla Bozor Oxund mosque and local madrasahs.

To achieve an accurate digital reconstruction, a three-tiered digital documentation workflow was established:

Terrestrial Photogrammetry and Remote Sensing**:** High-resolution digital cameras and Unmanned Aerial Vehicles (UAVs) were deployed to capture thousands of overlapping aerial and terrestrial photographic images of the exposed foundations, defensive walls, and surviving citadel elements of Akhsikent [Karimov, 112].

Terrestrial Laser Scanning (TLS): Spatial point clouds were generated using high-precision laser scanners to capture exact spatial coordinates (X, Y, Z) of

architectural surfaces, accounting for millimeter-level deformations, structural lean, and surface weathering caused by centuries of soil erosion [Smith, 78].

Parametric CAD and BIM Modeling: The raw spatial data (point clouds and polygonal meshes) were imported into parametric CAD environments (such as Autodesk AutoCAD and Revit). Here, historical architectural orders, brick-laying patterns, and structural modules were isolated and reconstructed based on mathematical proportions extracted from surviving fragments [Murodov, 55].

The historical source material includes archival drawings from 20th-century Soviet archaeological expeditions, descriptive accounts by medieval chroniclers (such as Babur's descriptions of Akhsi in the *Baburnama*), and comparative ethnographic data on Fergana architectural schools [Babur, 12]. The architectural data was classified into categorical databases, defining material properties, spatial coordinates, and chronological layers [Askarov, 204].

3. Results and Discussion

The implementation of engineering graphics tools yielded a multi-layered, interactive 3D digital model of the selected sectors of Akhsikent, including its monumental defensive gates and artisan residential quarters. The conversion of unorganized point clouds into highly structured parametric models revealed critical insights into the structural engineering logic used by ancient builders in the Fergana Valley [Askarov, 215].

One of the key discoveries made during the geometric analysis of the reconstructed fortifications was the precise proportional system governing the mudbrick (*paxsa*) layers and internal timber reinforcement frameworks. Engineering graphics software enabled the calculation of the structural loads of the massive walls, demonstrating that ancient builders utilized complex localized geometric adaptations to distribute weight evenly across unstable terrain along the Syr Darya riverbank [Murodov, 59].

To demonstrate the distinct advantages of this integrated digital approach over conventional architectural documentation, a comparative analysis was compiled during the study:

Documentation Metric	**Traditional Architectural Drafting**	**Digital Engineering Graphics & BIM**
Measurement Accuracy	Manual (centimeter-level errors)	Automated (millimeter-level precision)
Data Dimension	2D Orthographic projections only	Full 3D Spatial + Semantic Data (4D/5D)

Time Efficiency	Weeks of manual field sketching	Days of scanning and automated processing
Deformation Capture	Highly generalized or omitted	Exact representation of structural cracks
Interdisciplinary Sharing	Physical paper or static PDF files	Cloud-based interactive databases

Furthermore, the research successfully integrated these engineering outputs with the concept of **information culture**. Information culture involves establishing standardized metadata for digital architectural assets, ensuring that a 3D model is not merely an artistic visualization, but an open-source, scientifically validated repository of historical information. Every reconstructed beam, dome, or brick wall in the CAD environment was linked to specific archaeological databases containing information on material composition, excavation year, and confidence level of the restoration [Karimov, 142].

This systematic approach directly addresses a major problem in contemporary art history and museology: the proliferation of speculative, unscientific 3D models that misrepresent historical realities to the public [Smith, 102]. By embedding information culture within engineering workflows, any deviation or hypothetical reconstruction is transparently flagged, preserving the scientific integrity of Namangan’s architectural heritage.

4. Conclusion and Future Perspectives

The integration of engineering graphics with historical and art historical analysis represents an evolutionary leap in how Uzbekistan’s cultural heritage is studied, preserved, and disseminated. The application of these methods to the monuments of Namangan, particularly the complex site of Akhsikent, proves that digital reconstruction can uncover hidden structural logic that remains invisible to the naked eye or traditional manual drafting methods.

The main conclusions of this research indicate that:

- Engineering graphics provide an empirical foundation for historical conservation, turning passive observation into active, structurally sound virtual restoration [Karimov, 150].
- The synthesis of spatial data with semantic historical databases fosters a higher level of information culture among researchers and the public alike [Murodov, 64].
- Digital models serve as a permanent safeguard against the physical loss of monuments due to environmental and anthropogenic pressures [Askarov, 220].

Looking toward future perspectives, the established digital models of Akhsikent lay the groundwork for creating immersive Virtual Reality (VR) and Augmented Reality (AR) open-air museums directly at the archaeological site. This will allow tourists and researchers to visualize the ancient city in its original grandeur while standing amidst its ruins. Furthermore, the integration of Artificial Intelligence (AI) algorithms with CAD systems could soon automate the cross-referencing of regional architectural styles, enabling predictive reconstructions of missing segments of other ruined monuments across the Fergana Valley. It is highly recommended to establish a unified National Digital Heritage Cloud of Uzbekistan to consolidate these interdisciplinary datasets for future generations of scholars.

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