BIM-Driven Library for Islamic Architecture

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Abstract:

Islamic architectural records contain a considerable amount of information that need to be classified and modeled digitally so it can be used efficiently in the design phases of any project that seeks Islamic construction character. This paper focuses on creating BIM-driven three dimensional object library for Hejazi Islamic Architecture (HIAC) styles, construction methods, structural elements, and architectural components. It aims to enhance and reduce time and cost of projects that require Hejazi Islamic Architecture style. The main objective is to develop a BIM-driven (HIAC) library that contains guidelines for Islamic Architecture in general and in particular Hejazi Islamic Architecture components organized in accordance with the architecture category found in BIM authoring tools. The library provides designers with the essential data such as identifying the different models, shapes, and forms of construction, structures, and ornament of the HIAC construction. The application of HIAC plug-in BIM library is demonstrated in an example of modeling building elements.

Keywords: BIM-driven library, Islamic Architecture, Hejazi Architecture.

1. INTRODUCTION

Throughout history, Islamic Architecture (IA) has been regarded to possess distinguishing characters that describe regional variations in both Islamic and non-Islamic countries. These distinctions are observable in numerous buildings such as mosques, houses and gardens which employ unique arches, tile designs, towers and interior spaces. Islamic Architecture (IA) is a receptacle of Islamic civilization and it is significant that the interchange of these two facets be recognized when dealing with Islamic construction projects.

Grube (1987) defined IA as a set of architectural and spatial features, such as introspection, that are ‘inherent in Islam as a cultural phenomenon. Hence, establishing digital library of IA will assist in enabling a better understanding of IA while also providing a resourceful library for practical applications in the IA design domain. Currently, data and research efforts in digital Islamic Architecture is scarce. Examples of these research efforts comprise the work of Djibril et al., (2006) who developed a region based indexing and classification system for Islamic star pattern images using rotational symmetry information. Their classification system is based on the number of folds by which an image is characterized and the image’s fundamental region and class. Okamura et al., (2007) have likewise established semantic digital resources of Islamic historical buildings focusing on Islamic architecture in Isfahan, Iran. Their research work revealed that a topic maps-based semantic model applied to collaborative metadata management paradigms can be easily exploited as a tool to enhance traditional architectural design and interdisciplinary studies. Further efforts are shown in the work conducted by Djibril et al., (2008), who examined geometrical patterns in IA and developed an indexing and classification system using discrete symmetry groups. It is a general computational model for the extraction of symmetry features of Islamic Geometrical Patterns (IGP) images. IGP’s are classified into three pattern based categories. The first pattern-category describes the patterns generated by translation along one direction. The second-pattern contains translational symmetry in two independent directions. The third, which is called rosette, describes patterns that begin at a central point and grow radially outward. A more recent research effort on the topic is represented by work conducted by Baik et al., (2013, 2014, 2015). They used Terrestrial Laser Scanning and Architectural Photogrammetry to document a historical buildings in Old, Jeddah, Saudi Arabia. The data captured using these techniques was transformed into digital building information model (BIM).

The objective of this study is to create a Building Information Models for Islamic Architecture (BIM-IA) library with the intent of using the library as a repository for Islamic Architecture components. This BIM-IA library categorizes architectural elements and then sorts them chronologically based on their appearance in the IA timeline. The parametric three dimensional architectural elements are accompanied by schema, data, models, shapes, and both structural and construction elements. This paper focuses on developing libraries of Ottoman Islamic Architecture styles of the Hijazi Region. By creating a digital classification of the Hijazi Islamic Architectural Characters (HIAC), this work will assist future designers in better comprehending the HIACs once used in the Ottoman Empire. It also aims to serve as a method by which the future utilization and application of HIACs in
modern day buildings can be readily and efficiently employed.

2. METHODOLOGY

2.1 System of Classification

There are numerous publications and other resources related to Hijazi Islamic Architectural Characters (HIAC) that are not aggregated and assorted in one single BIM digital library. This work endeavor to enrich the HIAC architectural, structural, constructional elements by assorting and organizing the three dimensional elements in hierarchical classification system.

Almaimani & Nawari (2015a, 2015b) developed the general classification chart system of the BIM – Driven Islamic architecture library. This paper aims to demonstrate how the styles included in the BIM-IA classification system can be used to create a BIM library. The classification of three dimensional HIAC components is restricted to styles that have originated from the Hijaz region as indicated by the blue color outline in Figure 1. In this figure, the methods of classification used in the BIM-IA library are delineated. The first is the historical period in which the style can be found, which in this example is the Ottoman Khilaphia period. The second classification type uses building names as a category that then subdivides into subclasses of object types.

Figures 2 and 3 outline the hierarchical schema of the digital classification system used to organize the BIM-IA library. The data used to generate these figures is extracted from various Islamic Architectural references collected by the Aga Khan Program for Islamic Architecture (Islamic architecture - Aga Khan Documentation Center, 2015). Additional sources of data include: The Coral Buildings of Suakin by Jean-Pierre Greenlaw (1995), The Traditional House of Jeddah: A Study of The Interaction Between Climate, Form and Living Patterns by Sameer Al-Lyaly (1990), Suakin: On Reviving an Ancient Red Sea Port City by Abdel Rahim Salim (1997), and The Development of Housing in Jeddah: Changes in Built Form The Traditional to The Modern by Thamer Alharbi (1989).

The hierarchal schema presented in Figure 2 outlines the organization for the Ottoman time period and the Hijazi styles. For instance, if one seeks information about an HIAC window then that window’s origin, style, period and building could be readily identified. Figure 2 is also a representation of the general logic of classification and how well each object in the BIM-IA is synchronized. For example, windows and other components are each assigned a unique identification number (ID) that describes the design origin of each object so that other similar styles can be easily cross referenced. Figure 3 illustrates how all of the data found in Figures 1 and 2 are connected via a sequenced classification system that includes data on objects’ origin, style, and relationship to other similar objects.
Figure 1. Classification system showing Hijazi Islamic Architecture Character (HIAC).

Figure 2. Hierarchal schema of the digital classification of HIAC.
2.2 Schema
When a BIM-IA user selects an HIAC object such as window, that window will display various details about different designs, types and related information (Table 1). The schematic work flow with the library begins by seeing window details from figure 1, and proceeds to figures 2 and 3. As the user identifies and then selects a particular component, such as a window, details of that component are then displayed. Forty total HIAC components have been collected and classified so far in the BIM-IA library. Each component includes details that describe: component themes, element type, style history, character history, as well as additional architectural styles.
through the use of pictures and illustrations. All of these details will be essential to designers who seek to employ the HIAC into their buildings as well as to those who are interested in similar styles.

Table 1: An example of HIAC categorization for window details.

<table>
<thead>
<tr>
<th>Character</th>
<th>Hejazi</th>
<th>Suakin</th>
</tr>
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<tbody>
<tr>
<td>General Information</td>
<td>A- Differences: there are differences in vocabulary. In Egypt Bay Window called (Mashrabiyyah), the other areas in the red sea like in Jeddah and Suakin called Rawshan.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B- Elevational : 1- The External facades of Old traditional Jeddah buildings is distinguishable by their wooden fixtures, Main Doors, Rawshans (bay windows) and Taga (casement windows). P.56. 2- The External Features of the Jeddah Traditional Houses especially the sizes and ornamentations of the Rawshans gives a hint and a slight knowledge about the family residents of the house. Also, reflecting their society statuses and affluence.</td>
<td></td>
</tr>
</tbody>
</table>
|  | C- The facades of some traditional houses of Jeddah mostly draped in woodwork for casement windows and Rawshans. Those woodwork some of them attached horizontally, or vertically.  
D- There are Two Types: A- Bay Window, B- Casement Window. |  |

### Types: A- Bay Window (Rawshan)

1- Rawshan is the main element on the facade of Jeddah traditional houses. Every part in those bay windows constructed by lean wood, emerging out from the walls and based on cantilevered on wooden corbels. (P.58) F.2.16

2- Rawshans most of the time ornamented with complicatedly patterned panels, caves cornices and brackets. F.2.16.

3- Rawshan diverse in quality and size according to the owner financially and social status.

4- Roshan might build as a single unite or attached with other Rawshans in a vertical or horizontal directions and in some unique buildings in both directions. (P.58)

Roshan situated in the rooms which facing the north-east or North-west corner of the traditional house, by this way rooms receive the breeze.

Roshan (Mashrabiyyah) types:
2.3 BIM Components

Each HIAC architectural, structural and constructional object is defined and controlled by its parametric three-dimensional representation as well as the attached datasets described in the previous sections. Figure 4 below depicts the application of the BIM-IA library and explicates how BIM-IA components can be used in projects. Each element’s width, length, and depth can be defined to fit specific projects and these changes can be made to either the whole BIM component or only to a specific part of it.

Figure 4. Examples of application of the BIM-driven Islamic Architecture library.
Style: Ottoman; Character: Hijazi; Form: (a) Door way, (b) Arch: Agd Mawshah
3. CONCLUSIONS

The architectural information coupled with digital parametric models of Islamic construction is critically insufficient for designing contemporary project of Islamic styles. This study seeks to develop BIM driven plug-library of Islamic Architecture styles and representative three-dimensional models intended for use by architects and engineers. The intent of this research is the classification and organization of Islamic Architecture styles using spatial and temporal categories to represent the styles of different Islamic Civilizations. The prototype used to demonstrate the BIM driven plug-in is the Hijazi Architecture Character of the Ottoman Architectural period. Hijazi architecture was categorized based on components type and each component is paired along with a parametric three dimensional model that can be readily adapted. This informatics platform can be applied to existing projects to help accelerate project completion while also serving as method by which Islamic architecture can be integrated into modern day aesthetics.

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REFERENCES


