

*The 3D Documentation of Al-Jahili Fort in Al-Ain, United Arab Emirates (UAE):  
A Virtual Reality Application*

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*Abstract*

*This paper describes and documents the general procedure followed to create a complete 3D geometric model of the distinguished Jahili Fort located in Al-Ain, one of the major cities of the United Arab Emirates (UAE). The model was in-turn used for the development of a virtual reality 3D model that can be viewed and manipulated online.*

*The aim of this study is two folds. The first is to introduce an online easy-access tool for general public. This online tool would inform and increase the public awareness of their-own architectural heritage. The second fold, however, is to present a pilot example for architectural heritage documentation, recording, and online presentation. This pilot model can be applied in the future to other historical sites and buildings in the UAE. The initial results of the above mentioned effort are promising, and it should be further tested on several other buildings and sites.*

*Keywords: Architectural Heritage; Virtual Reality; Jahili Fort; United Arab Emirates.*

## Introduction

The conservation of historical buildings has always been one of the ways of preserving a country's identity and culture. Historical buildings have always been the pride of nations and their icons. In this paper, the authors are trying to highlight and present one of the most important cultural icons of the United Arab Emirates (UAE), namely, the distinguished Jahili fort.

Al-Jahili fort is one of the most famous historical forts in the UAE. It was constructed by Sheikh Zayed Bin Khalifa Al Nahyan (Zayed the First, 1855-1909) in 1898. The fort was built for defense purposes and to guard precious palm groves. It was also used as a residence for the local governor. The fort was constructed using mud-brick, stones, and palm-trees products. Al-Jahili fort was selected for this study because of its distinguished architectural and historical value, and also for its simple geometry and texture (Figure 1).

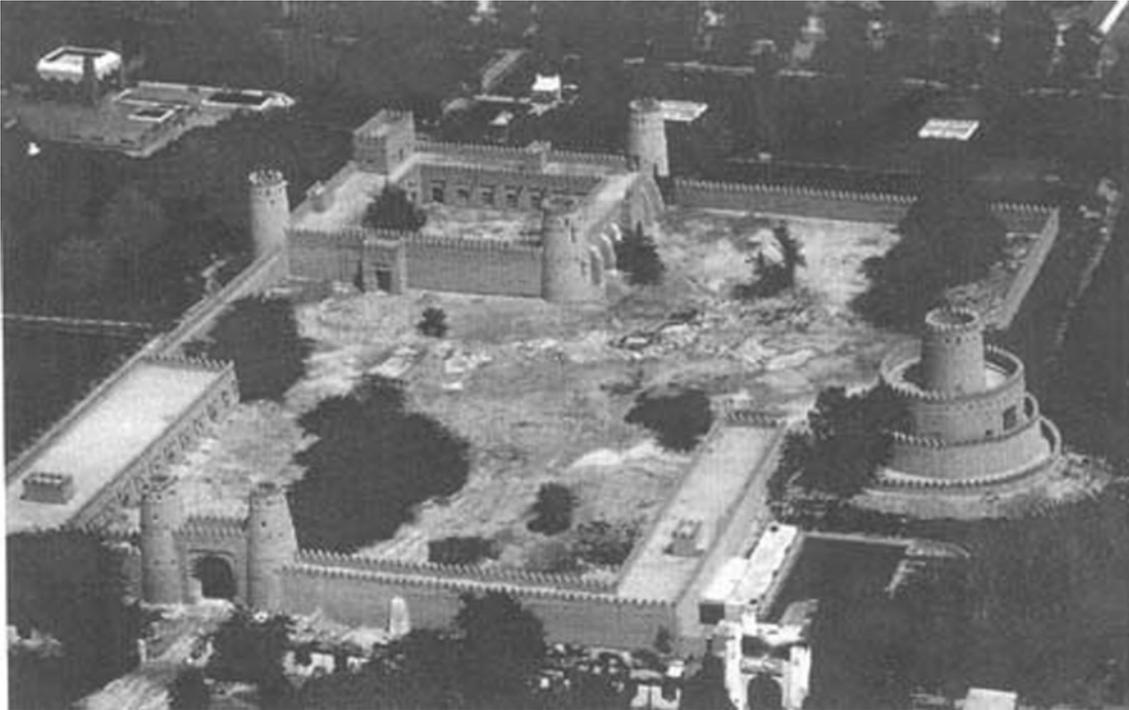


Figure 1: Al-Jahili fort simple geometry and texture

This work is a starting step in the effort of the 3D documentation of the architectural heritage in the UAE. It sets the stage for others to step-in and actively participate in this process. It also provides a working example to be generalized and followed by other teams. In the long run, this effort should cover the entire architectural heritage of the UAE and combine them in an online virtual library. This library would not only help in increasing the local cultural awareness, but would also help in introducing these cultural icons to the general public world wide.

In the next Section, a brief literature review of similar studies is presented. Section 3 illustrates the data collection methodology followed in this study. That includes: Written Histories; Photo Documentation; and finally, the Surveying of the fort. Section 4 describes the contents of the web-based documentation system. That includes: Web-based History documentation; Non-interactive Internet Based Picture Book System; Pseudo-3D-immersive Environments; Nested Pseudo-3D-immersive Environments; and finally, the production of a VRML-Based Virtual Model. Conclusions and future work are then outlined in Section 5.

## Literature Review

The Internet is rich with VRML models that document architectural heritage around the world. In the process of preparing this study, the authors reviewed a large number of similar web-sites. Some of these sites are listed below as online references.

One of the best online examples would be the VRND project on Virtual Notre-Dame. This example is unique because of it provides very high level of details for the interior of the monument. Another example is the Abbey of Pomposa. The surveying method adopted in this project --that is far more advanced than that adopted by the authors in this study-- made it possible to document even the very small details of the building. But unlike the Notre-Dame monument, the Abbey is much smaller.

Most of these sites present VRML models and rendered images from the 3D models. In this study, however, the authors incorporated 3D modeling with real panoramic-views of the existing building and its surroundings. Thus, mixing the virtual and the real fort to enhance the user's experience and take him or her as close as possible to the real scenes of the existing fort.

## Data Collection Methodology

There are three main pillars in the process of architectural heritage documentation. These three data collection modes include: (1) Written Histories; (2) Photo Documentation; and finally, (3) Site Surveying. The work progress in these three modes can be done in parallel in most cases. However, sometimes the history of the building can be the focus of the initial preparation for the documentation process, especially if the building has seen significant physical changes over its history. In the following sub-section, each of these modes will be separately discussed.

### Written Histories

In this data collection mode, all previously written history of the site were collected and studied to compile and verify a single story for the building. Interviews with previous users were also documented to further verify both the history of the building. They were also documented to verify the time period and the reason for each physical change that were done to the original building. The following briefly illustrates the history and the backgrounds of the building under investigation:

- Al-Jahili Fort has a great history. It was built on stages and witnessed many major events in Al-Ain. It started by building a massive round watchtower on a hilly location in Al-Jahili area. The aim was to safeguard the settlement from any intruder and to watch the water courses that were the essential means of living and survival in the oasis.
- The watchtower was built from mud bricks and it was inhabited by guards who used to watch the area day and night. A mosque was then built close to the watchtower for the use of the guards.

- Later on, in 1989 Sheikh Zayed Bin Khalifa (Zayed the First) built the rectangular fort. As he ruled the region during that period, the fort was used as his headquarter and as the ruling family residence.
- The fort was abandoned after the death of Sheikh Zayed the First since his son Sheikh Sultan moved to his fort at Al-Ain city centre (Sheikh Sultan Fort) and the watchtower was used as a storage facility.
- In the late fifties the fort was inhabited again but by soldiers as the area became a British Protectorate. The Oman Trucial Scouts --the representatives of the British Army in the region-- used the fort as their headquarters until the independence of the Emirates in 1970.
- Currently, the fort is the subject of a major restoration, preservation, and rehabilitation project. This project is sponsored and managed by Al-Ain Economic Development and Tourism Promotion Authority.

### Photo Documentation

In this data collection mode, digital images were used to photo-document the building with its different sections, feature, and architectural elements. These images also documents the physical state the building, including cracks, structural and finishing-materials damages, and the position of any missing ornaments or any other missing architectural element. They also record the current urban setting around the fort and its placement with regards to other buildings or urban elements. Digital Photos were meant to preserve visual information about the monument and provide a real visual feel of the fort structure, materials, texture, and its' current physical state.

### Surveying of Al-Jahili Fort

This data collection mode basically captures and records the actual dimensions of the fort to be later converted into two-dimensional drawings. In this case, manual surveying techniques were used to verify some old existing drawings from some previously done work. Following that verification process, all theses data were plotted in two-dimensional drawings for different plans, elevations, and sections. Finally, a three-dimensional AutoCAD model was constructed for the monument.

### The Digital Presentation of the Fort: Web-based Documentation

After the initial recording and documentation of the monument, several levels of digital online presentation techniques were used to publish this effort to the public. The aim of this digital presentation is two folds. The first is to introduce an online easy-access tool for the general public. The second is to present a pilot example for architectural cultural heritage documentation, recording, and online presentation that can be applied in the future to other

historical sites and buildings in the UAE. These different levels of digital online presentation techniques were all embedded and integrated into an Internet Web Site that includes the following:

## Web-based History Documentation

The history of the fort was embedded into a Web-based Document to be viewed by the general public. This web-text document includes all verified historical information as well as the verified stories of previous users of the fort. It also includes some old photographs and postcards of the fort that show the original settings of the monument (Figure 2).



Figure 2: Web-based History Documentation.

## Non-interactive Internet Based Picture Book System

Some of the previously mentioned captured images were used to create a Non-interactive Internet Based Picture Book System. In this system, the user can browse through a number of thumbnails that are categorized by subject, and then click to enlarge his/her choice for a closer look (Figure 3).

## Pseudo-3D-immersive Environments

Some of these captured images were also later used to create a number of Pseudo-3D-immersive Environments. Here, Pixmaker<sup>®</sup> was utilized to stitch a consequent set of images together utilizing the technology presented by Apple Quicktime. This process forms partial or full 360 degrees panoramic images of the monument site that can be displayed online. The user can literally look around the monument, and zoom in and out on demand (Figure 4).



Figure 3: Non-interactive Internet Based Picture Book System.

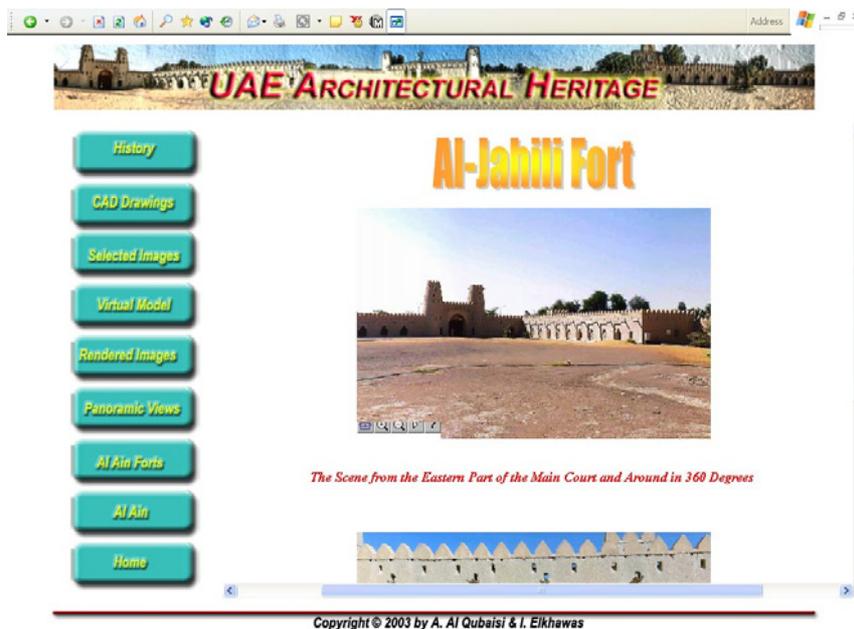


Figure 4: Pseudo-3D-immersive Environments.



Figure 5: Scenes from the Nested Pseudo-3D-immersive Environment

## Nested Pseudo-3D-immersive Environment

Some of these Pseudo-3Ds were later nested together in a sequence of immersive images that take the user from the front gate into the main court and then to the fort's inner court through a series of Hotspots. The aim is to introduce a user friendly way to explore all the external details of the monument while sitting at home, in a library, or in a class room anywhere in the world. Pixmaker<sup>®</sup> was again utilized to accomplish this task following a preset storyboard. This sequence of pseudo images takes the user from a position in front of the main gate into the main court. It then simulates a 360 degrees panoramic view of the court interior from more than one vanishing point. The 3D-immersive presentation continues by taking the user inside the inner court of the building through the southern door; simulate a 360 degrees panoramic view of the court interior, and then takes the user out of the western door. Finally, from a vanishing point in front of the western door, a 360 degrees panoramic view of the main court interior that includes the main cylindrical tower is presented (Figure 5).

## The Production of a VRML-Based Virtual Model

As a mentioned earlier in Section 3.3, a three-dimensional AutoCAD model was constructed using both the survey and the digital images. In this step, however, the aim is to produce a VRML model of the monument. This process started by exporting the 3D model from AutoCAD to AutoDESK VIZ 4. Since the model was huge in size (55 MB), several steps have to done to successfully import the model.



Figure 6: Al-Jahili VRML-Based Virtual Model.

First, the number of polygons was tremendously decreased by replacing some parts of the model with regular primitives and through unifying Faces and Normals. Then, the model was broken down into several small files that were later imported one by one and merged into a single file in VIZ 4. Still, the model contained an enormous amount of faces (literally, millions.) These faces were further decreased using the optimization modifier currently embedded in VIZ 4. Finally, a VMRL model was exported from AutoDESK VIZ 4 using the “helper.” This model was later embedded into a Web-page to be viewed and manipulated online (Figure 6).

## Conclusions and Future Work

The initial results of the above mentioned effort are promising, and it should be further tested on several other buildings and sites. The following conclusions have materialized from the above illustrated experiences:

- The process of surveying, documenting, recording and digitally presenting a monument of the size of Al-Jahili Fort has successfully enlightened our team of how demanding and time consuming similar tasks would be.
- Due to the monument present condition, the nested Pseudo 3D-immersive model is the best digital presentation of the monument. This is because of its simple geometry and the presence of the two wide courts that made the 360 degrees panoramic views possible.
- The virtual reality mode would be a great tool for the online exploration of the historical stages and of the details of all the architectural elements of the fort. This may be the subject of a future study.
- Moreover, the virtual reality model would greatly help in the process of rehabilitation and reuse of the fort. The model can be utilized through out the design process and later on in evaluating different design proposals.
- The product of this research work was not publicly presented in the UAE or tested by users. It is our future goal, however, to test the output of this study on a number of randomly selected users. This process would help us in evaluating the users’ response and modify our work accordingly.
- It is also our future goal to study the local cultural responses to the web-based heritage documentation system as an educational tool. The aim is to find out whether this process is a successful way of conveying the intended message to its’ intended audience or not.

## Online References

Abbey of Pomposa: VRML Representation

<[http://www.vit.iit.nrc.ca/Biris\\_Italy/pomposa/models.htm](http://www.vit.iit.nrc.ca/Biris_Italy/pomposa/models.htm)> (Accessed in January 2003)

The Virtual Tomb of Menna (Egypt) <<http://www.doc.mmu.ac.uk/RESEARCH/virtual-museum/Menna/visit.html>> (Accessed in January 2003)

VIRMLS Project; Virtual Open Air Museum

<<http://inf2.pira.co.uk/factsheets/inform/digicult/virmus.html>> (Accessed in January 2003)

VRND: Notre-dame Cathedral a Real-time Virtual Reconstruction <<http://www.vrndproject.com/>>