

The Use of Virtual Reality in Urban Design: Enhancing the Image of Al-Ain City, UAE

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1 ABSTRACT

This study aims at exploring the rapid growth of the use of Virtual Reality techniques in the field of Urban Design with application to the Al-Ain City. Currently, Virtual Reality and Virtual Environments are the most growing fields of information technology and have a great media attention. There is evidence to suggest that the use of such technology will enhance conceivable image of any proposed project at any urban setting for users, designers and clients. Therefore, city officials and administrators (clients) and the public (users) can reach better decisions regarding proposed projects within their towns and cities. Because of the limited time and resources, this study examines the visual quality of Downtown Al Ain, UAE, specifically, the Khalifa street (major shopping street). A basic VR model to the street was constructed. Modifications to the basic model were made to examine how changes in buildings' heights and street vegetation affect the visual quality of the street. Results of this study showed that urban visualization is proving to be a valuable tool for designers and planners. Increasing the heights of buildings in the mid-street and on the edges, along with enforcing distinctive architectural styles for the proposed buildings will enhance the overall quality of the street. Furthermore, decreasing the intensity of current vegetation and tree heights will increase the imaginable quality of the street. Nevertheless, the built of a comprehend VR model needs more time, resources and facilities that were not available to this study. This model, if completed, to the whole downtown area can be used both to identify existing problems and to quickly evaluate alternative solutions to those problems.

2 INTRODUCTION

Virtual Reality has received an enormous amount of publicity over the past few years. VR with its increasing dynamic, interactive and experiential characteristics becomes able to simulate real environments with various degrees of realism. For example, Regenbrecht & Donath (1997) have defined it as "...the component of communication which takes place in a computer generated synthetic space and embeds human as an integral part of the system..." Components of a virtual reality system include effectors, reality simulator, application, and geometry. Construction of the virtual environment passes through three main phases: modeling, rendering, and real time interactive presentation using system effectors (Okiel, 2001).

During the last decade there have been large-scale expansions in Virtual Reality applications in many disciplines (Pimental & Teixeira, 1995: 60). In the last few years, there has been a practical need in many fields of creation to visualize ideas before establishment (El Araby, 2002). The importance of environmental simulation is being crucial for almost all environmental design professions for presenting simulations of reality to the observer (client) to predict his responses of the real situation. McKechnie (1977) thought simulation techniques are crucial to decision-making process of environmental designers. The potential realities contained within a designer's imagination have been revealed through models, maps, plans, etc. (Watzek & Ellsworth, 1994; Zube, Simcox, & Law, 1987). Traditional simulation techniques were subject to intensive studies, and were criticized as they lack some important features that affect their reliability in predicting the real environment, such as the depth of visual field and passive interactivity. Virtual Reality could be classified into two main types according to the degree of immersion and interface in the synthetic environment (Mahmoud, 2001): immersive and non-immersive. In this study, only non-immersive methods will be utilized.

Making parts of the city pleasant to inhabit may go beyond the production of good looking buildings and into more functional domains. Some evidence to support this comes from a study carried out by an American sociologist William Whyte (1988.) The purpose of this was to look at the reasons why some of the parks and plazas in New York were more widely used than others. He found that a strong factor in the use of a plaza was the amount of space available for the users to sit down. What with hindsight seems like an obvious factor was far from being the first to be considered. Obviously, there is not likely to be a direct application of this to virtual worlds, where sitting may not be an option for some time, yet there is a lesson to be learned that the design of a good space may not depend entirely on what immediately springs to mind (Ingram, 2001).

Improving urban centers and edge cities was the focus of many urban designers to increase imagine-ability, connectivity and livability of the city (Jonathon, 2001). In his famous book (Image of the city) Kevin Lynch defined 5 variables that enhance the image of the city to include: paths, nodes, districts, edges and landmarks. Nasar (1998) defines a visual evaluation process that arises from the person, the environment, and the interaction between the two. Cognitive imagining processes represent important variables in human evaluative response (Nasar, 1998). According to this view, the model of evaluating the image of the city suggests two broad components of evaluative response-perceptual and cognitive-and two kinds of environmental variables-formal and symbolic. A recent study about studying the image of Long Beach Boulevard, Florida (Arroya, 2001) suggested that building usage, heights and massing, building' identity, setbacks, parking access and curb-cuts, service access, landscape screening, materials and colors are the major variables that affect the visual quality of the boulevard. To conclude, virtual reality is a very realistic valuable media that could be used to examine the image quality of any given area. Variables of examining and/or enhancing imagine-ability compromised both built and natural environments and human perception and cognition.

3 THE CASE STUDY

Al Ain is a sprawling city and is the largest city in the Eastern Region of the Emirate of Abu Dhabi in the country United Arab Emirates. Al-Ain is a city that is located on the junction of two major trade routes; that between Abu-Dhabi and mountain passes to the Gulf of Oman, and the other between Dubai and settlements south of Al-Ain. The modern development of Al-Ain came with the

successful exploitation of Oil in the Emirate of Abu-Dhabi and the foundation of the United Arab Emirates in 1971. During the subsequent period, a radical transformation of the area took place, which saw a modern urban development, a new population structure with particular socio-economic characteristics that includes locals, expatriates and non-local blend of population. Al-Ain has a special character as a garden city, not only just of the Emirates but also certainly of the Arabian Peninsula. Al Ain-oasis, retreat, university town, and granary- is the chief town of the Emirates' most fertile area and part of a large, historically critical oasis.



Figure 1: Satellite image of the city of Al Ain (adopted from SIME, 2001)

Development in Al Ain has been extensive with a special attention to preserve its character. Building heights, street setbacks, urban land use, urban growth boundaries and zoning are all measures that are enforced by the Al Ain Municipality and Town Planning Department to preserve this character. Building heights are restricted to max. 4 stories. This is why the city retains some of the atmosphere of a country town despite the gridiron layout of the streets.

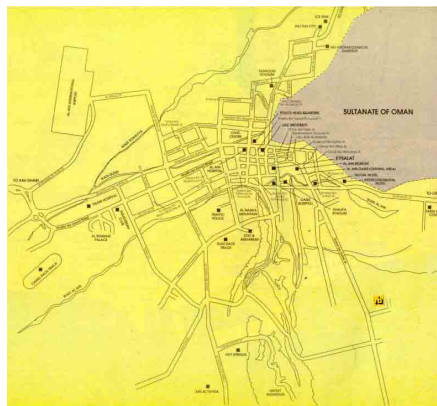


Figure 2: Al Ain Map showing the sprawl development of the city and the similar characteristics of streets and nodes

(source: UAE Interactive)

As a result, the physical characteristics of the city are dominated by major road and street network with roundabouts; horizontal expansion; extensive street vegetation and landscape; public gardens; availability of vacant and residential land; decentralization of the city services and the distinctive existence of the oasis within the urban fabric. Therefore, the downtown area of Al Ain has similar characters, where it is not easy to define and designate the area as a CBD.



Figure 3: Major features of the CBD in Al Ain have similar characteristics.

3.1 The study area

This research is concerned with the visual image of Al-Ain especially, the downtown area. Most of the area nodes and streets have similar characteristics regarding scale, form and composition. It is not easy to identify nodes and paths except some of those in the city-center area, however. Buildings are almost similar in the area, and more or less have similarities with other buildings in the city. The ambiguous landscape of the area made it hard to define edges or delineate boundaries of the CBD. Due to the limits of this research, the study will focus only on the Khalifa Street in the downtown area.

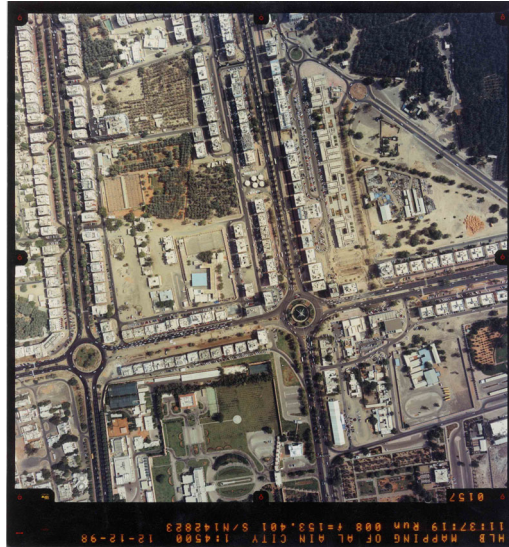


Figure 4: Aerial Image of the study area (Source: Department of Planning, Al-Ain, 1999)

The case study street is one of the major shopping streets in the CBD, however. Both physical and digital visual surveys were done to the area and revealed that the street image faces some problems: similar urban patterns, lack of orientation, identification of buildings, similar visual characteristics, loss of space and extensive visual obstacles.

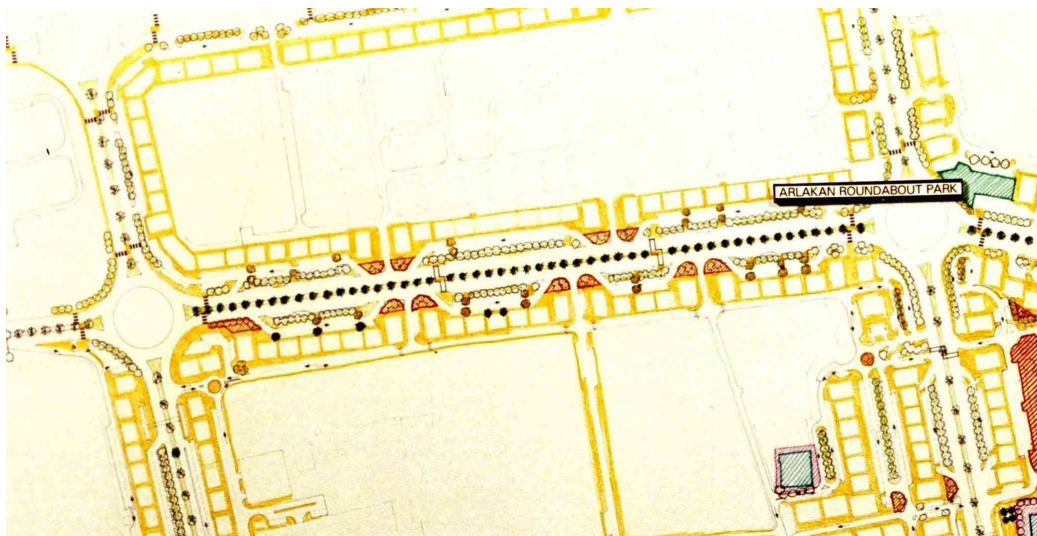


Figure 5: Map of the Khalifa Street (The case study area) showing similar urban pattern.

The reported visual problems of the street were the base of selecting the research variables. Review of previous research in the field suggested that increasing walk ability, diversity, quality architecture and urban pattern, connectivity, livability and density would enhance the conjectural image and identification of any proposed project (see, for example, Michael, and McCormick 2000). Therefore, two variables were selected for the purpose of this research: diversity (represented by building heights) and connectivity (represented by street vegetation and streetscape). The physical visual analysis of the street explicitly showed that the street has an identification problem to its different parts and sectors. Major buildings, shops and signs are hidden behind an extensive screen of trees. The monotonous character of the street architectural style made it hard to recognize or built a conjectural image to the street. Despite the major landscape works in the street and its nice streetscape, the street has no open space for public gathering except of parking lots and the motor street lanes. The results of the area visual analysis are summarized in the following table.

	Character	Variables			Total
	<i>Building Heights</i>	Below 12 m	Medium height of 12 m	Above 12 m	
No. of buildings		2	55 	5 	62
	<i>Building Arch. Style</i>	Modern / Distinct	Conventional/traditional	Unclassified	
No. of buildings		3	59 	-	62
	<i>Street Vegetation and Trees</i>	Clear view of buildings	Hidden view of buildings	Obstacles to view buildings	
No. of buildings		None	17 	45 	62
	<i>Streetscape, building signs</i>	Clear vision	Hidden vision	Searchable	
No. of buildings		8	6 	4 	20

Table 1: Visual analysis of the street.

A VR model for a CBD street, i.e. the case study, is developed to test the impact of changing these variables on the built environment. And is presented in the following section.

4 THE VR STUDY MODEL

Building a virtual model for the entire Al Ain city is a huge task which requires a budget, a working team and a time frame that are far beyond the limits of this research project. It was therefore decided that the area of Khalifa street in the central business district be selected to as a starting nucleus on which could expand later on by adding additional areas. Khalifa street was selected not only for its importance to the city but also because it is the most dense area in the city in terms of buildings, building details, vegetation, landscape elements, street furniture and traffic. For the purpose of this study, it was decided that the virtual model starts at a low level of detail that would increase over time as more aspects of the built environment are addressed and addressed. This model is the

basis for producing a documentation of the simulation model and presentation, as well as the findings of the research study as a whole.

Data were collected from both primary and secondary sources. Primary sources include: site visits, free hand drawings and sketches, documentation of digital photos, and digital motion “video” images. Secondary sources include: maps, aerial photos, previous studies about the area and planning reports (when available).



Figure 6: De-compilation and decimation of the video stream collected data

The collected data were used to develop a simulation model that relies on real data, evidence and conditions. This research work has links with a number of disciplines: photogrammetry, cartographic visualisation, three-dimensional surveying and positioning technologies. The model was constructed utilizing software that include: Erdas Imagine, Photomodeler, Photo3D, Pano tools (A software package for lens distortion correction), Lensdoc (A software package for lens distortion correction), Photoshop, Autocad2000, DMAX, Blaxxun, and Corotona.

The modeling process of the online virtual model built in this research project was planned to meet three criteria:

- Achieve a certain degree of realism,
- Meet bandwidth restrictions in terms of file size, navigation smoothness and download time and
- Easy to construct to meet budget constraints.

A sample building was modeled using the following three different methods to include: 1) a fully articulated 3D model with solid colors; 2) a fully articulated 3D model with generic texture maps; and 3) a semi-articulated 3D model with photo-based texture maps. The 3D models were investigated and compared according to the previous methods. Method 3 was found to offer the highest degree of realism followed by type method 2 and method 1. The model developed by method 3 was found to offer the least model size followed by method 1 then method 2. The model constructed by method 1, followed by model constructed by method 2 was easier to construct because they are fully described in the literature. Model constructed by method 3 was slower to construct and required further investigation and experimentation. Therefore, the basic model was constructed using the first method and the idea of a semi-articulated 3D model with hybrid photo-based and generic texture maps falls beyond the limitations of this research project.

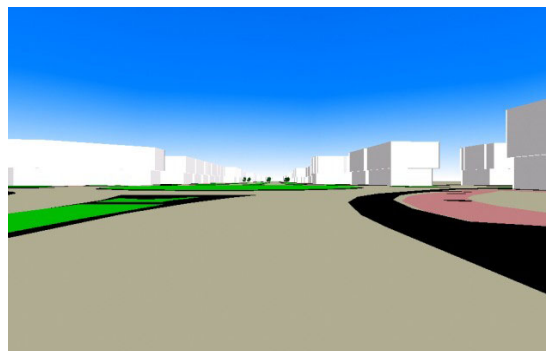


Figure 7: Model 1, fully articulated 3D model with solid colors

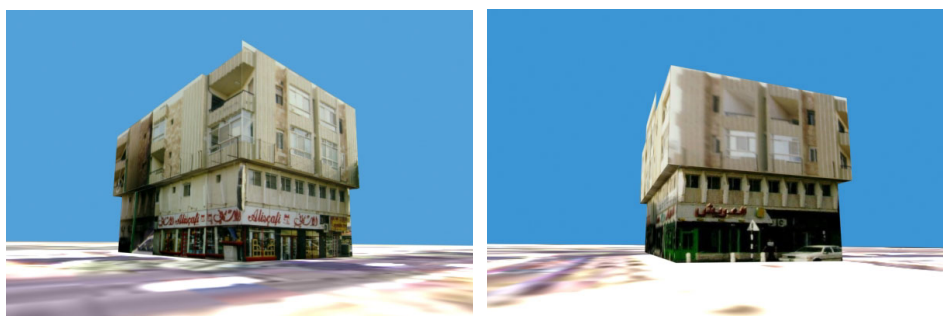




Figure 8: Pilot Model, semi-articulated 3D model with photo-based texture maps.

The 2D digital map obtained from Al Ain Municipality was the base starting point to build the 3D model on. The third dimension of objects was obtained either using judgment in the case of vegetation, measurement using an ultrasonic range finder in the case of masses projecting from buildings. Additional 3D information was obtained using desktop photogrammetry software such as photomodeler and photo3d. The geometric 3D model of the study area with streets, curb, walkways, green areas, trees and buildings but without textured maps and many other details was finished and tested on the Internet.

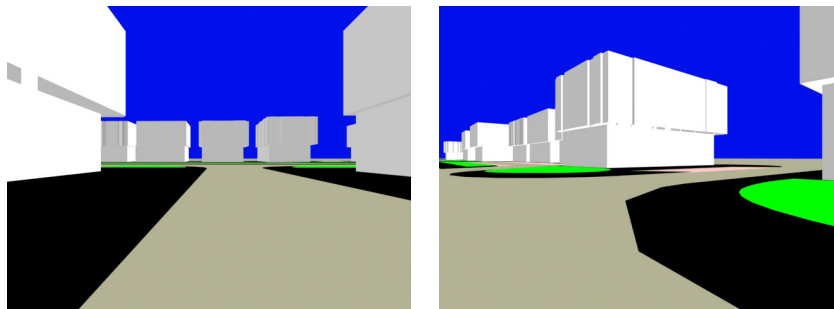


Figure 9: The abstract VRML online model of the study area.

5 RESEARCH RESULTS

The research variables were tested on the model to include building heights and street vegetation. First, all building heights in the area were raised equally to become 6 stories instead of the current 4 stories (stage 1). The automated model showed no difference in the street appearance. Second, the heights of some selected buildings in the edges of the street and in the anchors of the building groups were raised to reach 6 stories, but also, an insignificant difference was observed (stage 2). Third, alternate changes in building heights from 7 to 9 stories in the street edges and in the middle started to show some difference in the model (stage 3).



Stages 1 and 2



Stage 3

Figure 10: Examination of changes of building heights on the street image.

In the context of studying the street vegetation (trees types, dense and heights), it was clear that the current arrangement of trees, and the dense existence of trees, palm trees and shrubs in the streets both sides and in the middle created a major obstacle to the street

image. Trials of changing the current street vegetation pattern include: reducing the current number of trees by 20%, 40%, and 60% respectively. The model shows no major difference in the overall appearance of the street, except that inner buildings and shop signs started to be noticed when number of trees was reduced by 60%. Furthermore, in that model, both sides of the street started to be visually recognized due to increase openings in the mid street that may increase the conjectural image of the street.

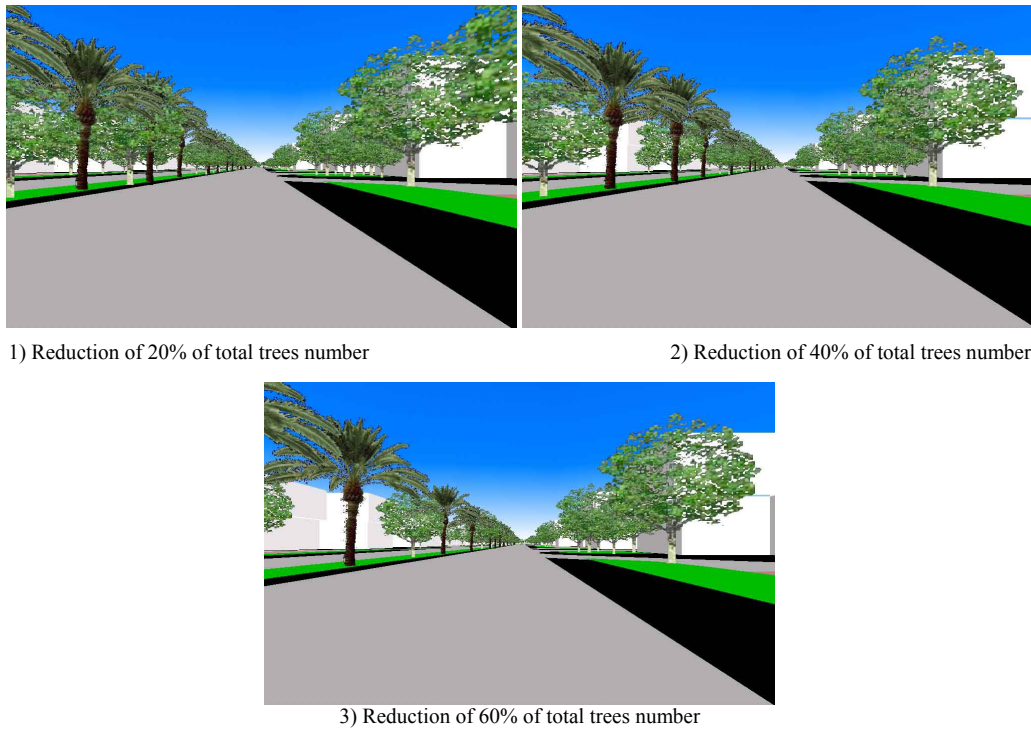


Figure 11: Results of changing the street vegetation on the VR model.

Another trial of changing the trees type, height and density was employed. The first trial included the change of the whole street vegetation from trees and palm trees to be all palm trees. Results of that model depicted that the use of palm trees may, on one hand, increase the identification of the street sectors as it gives opportunity to vision penetration, while, in the other hand it decreases the visual quality because of monotony.



Figure 12: Effect of changing the whole street vegetation to palm trees.

Changes of trees type from the current type (mostly evergreen) to other more root height types proved to increase the visual appearance of street shops. Changes of both density and types appear to have significant change of the overall street image. In the same time, changes of building mass in term of height and changes of trees types and density showed significant difference in the visual quality of the street.



Figure 13: Results of changing trees heights and types.



Figure 14: Results of combined changes of street heights along with trees density and types.

It can clearly be seen that incorporating more than one variable in the model leads to more realistic results. The option of changing variables is endless, however, the study model proved to be a good, reliable and malleable tool to detect the impacts of changes on the built environment of the study area.

6 CONCLUSION

Urban visualization is proving to be a valuable tool for designers and planners. The ability to visualize potential modifications to the urban fabric and experience these changes in their actual context allows planners and designers to evaluate alternatives rapidly, in more detail, and for lower cost than through more traditional analysis. It also makes the results of the planning process visible, allowing the public to view the proposed changes to their environment in a realistic fashion. VR proved to be advantageous in several phases of improving the urban design of the studied area. However, several shortcomings in both hardware and software became apparent. Experiences gained from rebuilding the study area would help set guidelines and develop techniques to face easier situations existing in other areas of the city. Even though, building a virtual model for the entire Al Ain city is a huge task which requires a budget, a working team and a time frame that are far beyond the limits of this research project. If resources and time would be available, the city VR model can be used both to identify existing problems and to quickly evaluate alternative solutions to those problems. Its potential as a tool for analysis of complex urban problems is significantly increasing.

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