Narrative Models:
A Database Approach to Modeling Medieval Cairo

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ABSTRACT

This paper explores the use of three-dimensional simulations to investigate transformations of urban form in medieval Cairo, and lessons about using computers to support historical visualization. Our first attempt to create a single extremely detailed model of Cairo proved unworkable. From this experience we developed a database approach to organizing modeling projects of complex urban environments. The database consists of several complete models at different levels of abstraction. This approach has three advantages over the earlier one: the model is never viewed as incomplete, the framework supports both additive and subtractive chronological studies, and finally, the database is viewed as infinitely expandable. Using modeling software as a tool for inquiry into architectural history becomes more feasible with this new approach.

INTRODUCTION

In his paper “Bayn al-Qasrayn: The Street between the Two Palaces,” urban historian Nezar AlSayyad traces the development of al-Qahirah, as medieval Cairo, Egypt was called, by using writings of travelers who visited the city. Many of these travelers who wrote between the eleventh and sixteenth centuries described the Bayn al-Qasrayn, the principal street of the city. For example, the traveler Nasiri Khurshaw, who lived in Cairo from 1047 to 1050, wrote (Khurshaw 1047):

“The Caliph’s palace lies in the middle of al-Qahirah. It is a freestanding structure detached from all its surroundings. It is guarded at night by a hundred guards who circle it all the time. You can see the palace from outside the city because of its high walls... These also help to define the different gates of the palace, many of which lead to the great space, Biyn al-Qasrayn.”

Historical texts such as this one provide an incredibly rich source of information about the appearance of medieval Cairo. Descriptions of the Bayn al-Qasrayn are particularly important to understanding the city. Because it contained numerous monumental buildings, such as mosques and palaces, as well as ordinary buildings, the Bayn al-Qasrayn provides an opportunity to explore how people move through the street, both inside and outside of the buildings.

AlSayyad uses texts describing the Bayn al-Qasrayn to point out differences in the descriptions of this street by various travelers. Occasionally, these travelers offered radically different descriptions of the city from within a relatively short period of time. For example, a text from 1193 describes a city “characterized by palaces, detached tall buildings, and wide streets,” (AlSayyad 1994) while an account fifty years later paints a different picture (Ibn Sa’id 1243):

“If all of al-Qahirah was like it (the Bayn al-Qasrayn), it would have been a great royal creation. But you walk through the space and then you find yourself in a dark alleyway with shops, people, and horses, making your breathing heavy and your eyes hot... Most of the streets of the city are narrow, dirty, and dark, surrounded by mud brick houses with little air and light. I have never seen in the Maghreb anything as bad as this.”

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Because both travelers are reputed to be accurate interpreters of urban form and give essentially similar accounts of other cities, AlSayyad concluded that Cairo did in fact undergo a radical transformation during this period (AlSayyad 1981). The assertion is supported by political and cultural changes in the city, which would have made such a change possible.

From an urban history perspective, research into Cairo’s transformation during this period is significant because it provides a new view of medieval Islamic cities. These cities are typically recognized for their tremendous irregularity and labyrinthine street structure without geometric order. However, this description is not applicable to early Cairo, which was planned as a royal city to house a new Caliph and his family. As a palatial compound, Cairo originally had a rectilinear geometric form, and slowly evolved into an organic, irregular city through complex transformational processes. Figure 1 shows plans of the city from 1169 and 1517.

![Figure 1. (Left) The Bayn al-Qasrayn in 1169. (Right) The Bayn al-Qasrayn in 1517.](image)

FROM NARRATIVE TO MODEL

To reconstruct plans of cities, architectural historians typically use a variety of source materials including: archeological evidence, textual descriptions by residents and travelers, city or building records, maps of the city at various time periods, artists’ representations, and documentation of still-standing buildings. From these materials, historians interested in exploring the urban fabric may be able to construct two-dimensional plans of the city, and engage in analysis, such as figure-ground and massing studies.

Our approach to modeling medieval Cairo relied on the usual sources, but produced a different product: a three-dimensional computer model. Because computers can deal with the complexity of representing the city at various levels of abstraction, they are an effective tool for exploring transformation of the urban fabric. Simulations are attractive to architectural historians because they are useful for both extremely abstract studies, such as figure-ground analysis, as well as specific comparisons of building-level details. The ability to juxtapose conflicting accounts of the urban form is valuable, because in these representations even minor discrepancies can be shown to have significant and far-reaching implications for the character of the city.

Increased modeling and animation capabilities overcome some of the limitations of paper-based media by providing scholars the means to explore the city with a level of immersion previously impossible. Modeling and animation can allow historians to visualize the evolution of Cairo’s street pattern as the original grid disintegrated into the organic form it sustains today. Photo-realistically rendered walk-throughs at eye-level can provide a simulation of how the urban fabric was actually experienced by residents of the city during the medieval period.

In addition to these advantages, we wanted to explore two further opportunities afforded by CAD simulations. First, through metamorphosis (morph) sequences, the models can facilitate an understanding of change over time impossible by traditional paper methods. Second, the tools provide an opportunity to animate not only the buildings, but the people using them as well. This potential to see how people used the space of medieval Cairo will

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provide researchers with a new experience of the city as a dynamic organism composed not merely of buildings, but also of a society which inhabited them. Like the art work of the eighteenth century, including people in the spaces could provide a small glimpse into how life went on in Cairo.

With these two objectives in mind, we began using Alias® and SoftImage® software running on a Silicon Graphics Indigo Workstation to create separate three-dimensional models of Cairo during the years 969, 1169, and 1517. These years correspond to the three dynasties in the history of the city. The models were developed from a group of representations of the city collected at the Center for Environmental Design Research since 1989. They include: maps of the city; plans, sections, and elevations of significant buildings; photographs of buildings still standing; three-dimensional CAD models; textual descriptions of buildings; and images of eighteenth and nineteenth century art works depicting areas of the city and its inhabitants. Figure 2 shows an example of a painting representing the Bayn al-Qasrayn.

![Image](image_url)

**Figure 2.** The Silk Merchants’ Bazaar, David Roberts, 1843.

Working from these three base models and our collection of images, we planned to record two products on videotape: 1) an animation showing the dynamic processes of urban transformation from the early (969-1169) to late (1169-1517) medieval periods, by linking them with a morph sequence; and 2) a walk-through simulating a stroll down the Bayn al-Qasrayn. We began to modify the original base models by replacing the primitive masses of significant buildings with more complete models with detailed facades and interior spaces. Figure 3 shows an example of such a building. We planned to continue adding detailed buildings until all the important buildings (twenty-six) on the Bayn al-Qasrayn were completed. By working in this way, we intended to allow users of the
system to choose their own path along the street and which buildings they enter, affording them a different experience than the one recorded on tape. These walk-throughs would use Alias to allow the students to explore the rendered base model of the city. Navigation through the model of the city would be quite limited by the availability of detailed buildings.

Using a base model and adding detail is the traditional approach to modeling cities, and there are myriad examples of projects following this procedure. Some examples include Grabar’s model of Jerusalem (Grabar 1994) and Jepson and Liggett's of Los Angeles (Jepson, Ligget, and Friedman 1995). By following these examples, we attempted to create an extremely flexible model of medieval Cairo. We assumed that the more detailed the model the better, and that the model should not be targeted toward a specific purpose, but rather be as neutral as possible in order to provide the greatest flexibility in application. We wanted a model appropriate for multiple purposes or kinds of representation, ranging from the figure-ground studies to walk-throughs.

![Figure 3. Talia Mosque created using Alias.](image)

**THE FUTILITY OF A COMPLETE MODEL**

Our attempt to create a model of this type proved to be problematic in some unexpected ways. We were unable to follow the usual approach to modeling Cairo for two main reasons: first, limitations of the historic source material, and second, the files became unmanageably large.

Historical reconstruction is an inexact practice. Historians rely primarily on a combination of various sources to engage in historical reconstruction, and the results may vary widely depending on the source. The materials we used to represent medieval Cairo span a wide range of accuracy and abstraction. They include everything from unreliable texts from the eleventh century to the x, y, and z coordinates of our CAD models. The leap in specificity from one to the other implies a level of certainty totally inappropriate for architectural history research. The difficulties of trying to make models based on sources with irreconcilable differences exposed two kinds of discrepancies: differences in details of the same level of abstraction and differences between various levels of abstraction.

One example of a discrepancy between sources of the same level of abstraction is differences in buildings represented in artists’ representations. We know that some of the details in the nineteenth century paintings of Cairo are inaccurate. Because the artists were less concerned with documenting urban form than selling paintings back in Europe, they often took the liberty of combining elements from different parts of the city, and even borrowing details from different cities to create a balanced artistic composition. Although use of these images to communicate history...
can be extremely misleading, researchers generally agree that they can be useful if treated carefully and clearly designated as abstractions. However, in order to use these images for the purpose of creating simulations, extra attention is required to extract kernels of factual information, and distinguish these from artistic license.

A discrepancy between different sources of different levels of abstraction arose in deciding how to model building footprints in order to conduct figure-ground analysis. In this project we have sections of the model for the year 1517 that are extremely accurate; the footprints of the buildings are historically well-established. However, to have a full view of the city during this year, we had to extend the model to include other buildings whose footprints are much less certain. Because scholars have determined certain facts about courtyard size, living patterns, entrances, and street-widths, we were able to construct an abstract pattern of “urban fabric” that is similar to pieces of the fabric which have survived.

By developing rules for courtyard placement and area (ex. rectangular houses have rectangular courtyards, square houses have square courtyards, the area of the courtyard is fifty per cent or less than the area the house, etc.) we have been able to design a pattern of urban fabric for the city during this period.

We encountered another example of difficulty in determining what level of abstraction was appropriate for the model in deciding what to include in the space between the buildings. Because we were interested in modeling the transformation of the city from a rectilinear grid to an organic form we had to include all kinds of structures which contributed to this change. Our analysis of the urban fabric tried to examine not only the buildings, but also the extension of shops into the public space.

For example, during Cairo’s early years, the entire city was a military compound inhabited only by members of the royal family and the army. Merchants and artisans came into the city each day, set up their shops, and left each night before the gates were closed. After a change in government, these merchants were not required to leave Cairo for the night. Many of the merchants built dwellings for themselves in the former palace gardens and built shops in the streets where they sold their wares. To understand how this process contributed to the street pattern’s disintegration into an irregular form, it would be beneficial to model not only the buildings, but the movable structures, people, and animals in the streets. However, this raises serious issues about how abstract the simulation is intended to be, and how to indicate that level of abstraction to those who view the simulation.

In addition to the difficulties in modeling medieval Cairo caused by the limitations of our sources, we also encountered computational problems. The most serious of these was file size. Because the urban fabric of medieval Cairo was so incredibly complex, the models contained hundreds of thousands of polygons. With 208 megabytes of animations our models were still incomplete. The attempt to make a single three-dimensional model of the city containing everything from building level detail to the entire urban fabric resulted in files unmanageably large. The importance of ornament and proliferation of curves in Islamic architecture also contributed to very large files. Once detailed models of elaborate buildings, such as palaces and mosques, were added to the base models of the entire city, the files became so large that they could not be manipulated quickly enough to be useful. Despite using a Silicon Graphics Ctxsion workstation, we did not have enough computing power to manipulate the models in a reasonable amount of time, and the traditional approach to modeling encountered very limited success.

A DATABASE APPROACH

After determining that a single model containing all our information on the entire city was too complex to manipulate, we modified our approach towards designing the walk-through. We switched from attempting to create a general model with several uses in mind to designing the walk-through as a deliberate presentation. Once we viewed the walk-through as a composition in itself, we appropriated the multi-media technique of making storyboards. Our storyboard included two kinds of views: those essential for representing the transformation of medieval Cairo, and those necessary for exploring the city in the interactive walk-through mode. Figure 4 shows an early storyboard for viewing the transformation of Cairo.

From the storyboard we constructed a table showing what kinds of models would be necessary to complete the walk-through. Instead of trying to create complete models of various years, we began to design a database consisting of various incomplete models at different levels of abstraction. Figure 5 shows this database. The walk-through would then consist of a presentation derived from a kit of parts from the various constituent models. There were several spaces in the table for models that we did not believe to be relevant for this particular walk-through. However, a place is held for them in this table, indicating that they could be included at a later date.
Once we began using this database approach to modeling the city we stopped adding detail to the base-model and started dividing the base-model into the individual models indicated above. These smaller models were then animated as individual segments. These segments were linked using Macromedia Director® as a presentation medium. Viewers play the free-standing Director movie to navigate through the various models and interactively select which animations they view, along with other supporting material such as still images, text, and sounds. In this multi-media presentation, the structure of the database is hidden. The database is a tool for organizing the creation of complex modeling projects, not for the presentation of models. When users select which animations they wish to view, the names of their choices do not resemble the model names indicated in Figure 5.

<table>
<thead>
<tr>
<th>MODEL NAME</th>
<th>Massing - Courtyards Painted On</th>
<th>Massing - Courtyards Modeled</th>
<th>Facades Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>969 Entire City</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1169 Entire City</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1169 Bayn al-Qasrayn</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1169 Gate Area</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1517 Entire City</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1517 Bayn al-Qasrayn</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Models Necessary to Provide a Walk-through.

Advantages of the Database Approach

This database approach to modeling complex cities has three primary characteristics which address some of the shortcomings of the traditional approach outlined above. First, the model is never viewed as incomplete; second, the framework supports both additive and subtractive chronological studies; and third, the database is viewed as infinitely expandable.
In the database approach, the project is never viewed as incomplete; rather, it is viewed as an assembly of discrete models. The project is always complete because "the project" is defined as the assembly of the parts of the database already available. Viewing a project as an assembly of various components provides a crucial organizational structure for managing complex projects with long life spans. This organization becomes particularly important when multiple people are working on the project over a long period of time.

In the case of Cairo, we began working on this project in 1989. Since that time the number of models and their level of detail have grown. However, all the input has not been carried out by the same researchers. Typically there have been periods of intense activity right after receiving more funding, followed by a dormant period. When there is a renewed interest in adding to the model, it has proved difficult and time consuming to determine where new work should begin and how to link new models with the existing ones.

A second characteristic of the database approach is that the model is conceived of as discrete models lacking chronological order. This lack of chronological order is significant, because the convention of starting a model in the earliest year and then changing it as we move forward in time is not always logical. For example, in making models of Cairo we have used both an additive and subtractive chronology for examining the metamorphosis of urban form. The most complete and reliable map of Cairo we have was created in 1801 during the Napoleonic Expeditions into Egypt. Beginning with the 1801 map, we have been able to remove buildings known to have late construction dates. Through this process of removal, we can begin to approximate a map of the city in 1517. However, because we have more complete descriptions of the expansion of city during the 969 - 1169 period, it has been easier to begin with the best approximation of the city for 969 and add structures to construct the form in 1169. The database approach allowed for the co-existence of both the subtractive and the additive modalities.

A third characteristic of the database approach to modeling complex cities is that the database is viewed as infinitely expandable. This expandability benefits architectural history research because after a new topic is selected for investigation and a need for a new kind of model specified, a place is held for the new model in the database. For example, if archeological investigations produce new information about window details, a model element not previously considered, the sample database in Figure 5 could be expanded with a new column called "Window Details." Figure 6 shows a modified Figure 5 with additional columns indicating additions to the database.

<table>
<thead>
<tr>
<th>LEVEL OF ABSTRACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL NAME</td>
</tr>
<tr>
<td>969 Entire City</td>
</tr>
<tr>
<td>1169 Entire City</td>
</tr>
<tr>
<td>1169 Bayn al-Qasrayn</td>
</tr>
<tr>
<td>1169 Gate Area</td>
</tr>
<tr>
<td>1517 Entire City</td>
</tr>
<tr>
<td>1517 Bayn al-Qasrayn</td>
</tr>
</tbody>
</table>

Figure 6. An Expanded Database.

The addition of these columns is a powerful tool for focusing architectural history discussions because it records not only the model, but discussion about the evolution of the model as well. Ease of addition of new information is crucial because during the life-span of a project such as this, there will certainly be numerous additions to the collection of sources, as well as new causes to doubt data from others.
CONCLUSIONS

From our research we have concluded that creating three-dimensional CAD models is very useful for researchers wishing to engage in historic reconstruction of urban fabric. The most effective approach to managing large and complex modeling projects is not to view the project as one complete model, but rather as a database of several models at various levels of abstraction. This database approach provides a flexible framework for organizing simulations. Although this approach to simulation has been helpful in understanding the transformation of medieval Cairo, our investigation has raised some issues for further consideration of the applicability of CAD simulations in architectural and urban history research.

First, the difficulty of indicating the intended level of abstraction of a simulation may inhibit historians’ acceptance of CAD images. Those who engage in historical simulations using modeling and animation must be careful to avoid the pitfalls of merely creating abstract compositions, similar to the nineteenth century artists. Simulations are extremely powerful, and even relatively minor points intended to be abstractions, such as the choice of colors of a dress or fruit for sale in a market, may mislead those who view the simulations. These pitfalls become all the more apparent when addressing crucial issues such as modeling people.

Second, despite the increasing use of computers in the arts and humanities, architectural historians might believe a CAD representation of a building is intended to be one-hundred per cent accurate, just because it has $x$, $y$, and $z$ coordinates. Architectural historians are often reluctant to include three-dimensional computer-generated images in their publications because their peers may immediately question aspects of the forms which cannot be fully verified. Two-dimensional data, such as plans and maps are considered more appropriate for abstraction because they raise fewer questions and are easier to substantiate. This points to a major difference in how scholars in different disciplines may use three-dimensional CAD models.

Our experience with using three dimensional models to understand the transformation of the urban form of medieval Cairo has been quite successful, and there is clearly a great opportunity to further architectural history research using the database approach to modeling cities. However, in order for modeling to be successful for historical reconstructions, the models must be treated as abstractions. Treating the models as abstractions requires both that historians be able to tame their desire for complete reliability, and those who make models add only details consistent with the intended level of abstraction.

REFERENCES


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