Digital Reconstruction of Medieval Chinese Cities

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1   Introduction

The study and teaching of Chinese urban planning particularly of the earlier periods is heavily handicapped by the lack of pictorial or physical evidence. This is mainly due to the perishable nature of Chinese traditional construction which depended heavily on timber for both its structure and infill. Large architectural complexes were torched during wars and entire cities destroyed during dynastic upheavals. The Tang (618-906) capital of Changan is a classic example. Perhaps the foremost city in the world during the seventh and eighth centuries, it was reduced to wasteland by the beginning of the tenth century [1]. The city now lies a little below the modern city of Van, which occupies only a fraction of the Tang capital. The Northern Song (961-1127) capital, Kaifeng, also suffered similar fate when warfare and natural disasters eradicated the Song city. The ruins are buried five to twelve meters beneath present day Kaifeng. The earliest surviving imperial city is Ming (1368-1644) Beijing. By comparison, there are still substantial ruins from Athens and Rome in the Western world.

The study of Chinese urban planning and the understanding of past urban structures are important as the influence of these urban structures are still discernible in historic Chinese cities today. While traditional Chinese architecture is perishable, traditional urban planning principles leaves their imprints much longer despite the frequent replacement of the physical urban fabric.

1.1   Urban Structures

Modern urban interventions in Chinese historic cities have to take into consideration urban fabrics and structures inherited from previous eras. Two significant ones that are still legible in historic cities stemmed from the Tang and Song periods. They still contribute much to the existing urban landscape. Although these urban structures date back to around the eighth and twelfth centuries respectively, they still left traces in historic cities after the Tang period. The strict gridiron planning typical of Tang China as was epitomised in the layout of Tang period Changan and Luoyang can be seen as the backdrop to most historic Chinese cities. This strict rectilinear orthogonal grid defined by streets and lined with walled wards began to break down during the Song period. Ward walls were demolished and occasionally oblique streets were introduced. Cranked roads were also more common.

A clearer understanding of these urban structures and cityscapes will, I hope, help students, practitioners, and academics working on historic Chinese cities to appreciate better the urban environment they are studying and help them make more informed decisions when making interventions.

2   Changan and Suzhou

This paper reports on an ongoing project to reconstruct on computer the cityscapes of two of the most important cities of the Tang and Song periods-Changan and Suzhou. While Tang Changan epitomized the disciplined gridiron city that became the ultimate symbol of rule in East Asia, Suzhou of the Song period represents the evolution of the Tan model and became the prototype for premodern Chinese cities and capitals. Changan and

Suzhou are both good examples of urban structures from their respective periods. The controlled and highly ordered cities of the early Tang periods gave way to open cities with a less rigid framework during the Song period. This dramatic change in urban structure created very different cityscapes. This paper reports on the preliminary results of a research project currently conducted at the School of Architecture, NIJS, that attempts to reconstruct on the computer the cityscapes of Tang Changan and Suzhou to provide visual, formal, and spatial information critical to our understanding of the development of Chinese cities.

2.1   Chang'an

To begin with, Tang Chang'an was no ordinary city. The capital was built from scratch by the short-lived but powerful Sui dynasty in A.D. 581. Thirty-seven years later, in 618, with the founding of the Tang dynasty, it became the capital of perhaps the most powerful empire then. The city was immense in size, even by modem standards. It measured 9.721 km by 8.652 km or about 84 km2 in area. A perimeter wall of rammed earth, 36.7 km in length, was built around it. Further protection was offered by a 9 m wide moat.

Within these walls, fourteen latitudinal (E-W) and eleven longitudinal streets (NS) divided the city into an axially symmetrical plan of 108 wards, large and small[2]. North of the center were the fortified Imperial and Palace Cities which housed the command and bureaucratic machineries of the empire.

A very long and very broad street - Vermilion Bird Road or Zhuquemen Dajie provided the central axis of Changan. This road linked the imperial complexes to the city's main south gate. Measuring 150 to 155 meters or the equivalent of a 42-lane modern highway, this principal avenue divided the capital into two halves. Like all other roads in the city, it was made of compacted earth and tree-lined.

Five other principal avenues were equally awesome at widths of between 120 and 134 m. The other major thoroughfares, measuring between 40 and 75m, were also very wide by today's standards. On both sides of the roads were 3 m wide ditches that helped in drainage and irrigation.

The rest of the city contained the 108 walled wards in which were found houses large and small, religious establishments and occasional government offices. Such wards varied in size ranging from about 1.1 km by 800 m to 580 m by 530 m. The larger of these wards were divided into quarters by two main streets connecting the four ward gates. Residents were allowed out of the wards only during the day. The opening and closing of the ward gates were announced by 300 and 800 drumbeats respectively. Commercial activities were similarly confined to two large fortress-like East and West markets and trading was permitted only during certain hours. The city was extremely controlled. The closely patrolled streets that separated the walled residential wards became vast expanses of "no-man's land" at night. Access to the streets after dark was strictly regulated. Guards stationed in police posts located at junctions of the avenues at the corners of the *fang* enforced compliance. In fact Chang'an was very much like a collection of semi-autonomous walled cities or urban "villages" separated by wide avenues within a fortified precinct.

2.1.1   Computer Modelling

The sheer physical size of the Tang capital and the nature of its terrain preclude seeing the capital all at once. Any premodern endeavour (and there were several) to represent the city graphically stemmed more from the translation of an intellectual understanding of the city than from an actual visual perception of the entire city. These graphic depictions were attempts by scholars and artists alike to record the capital city and to render them more comprehensible to the beholder. While this is probably achieved as far as understanding the urban organisation or structure is concerned, they failed to inform us of the cityscape, or worse, misinform us of the cityscape. Even a recent attempt to represent the city was unsuccessful in showing the cityscape of the capital. The vast scale of the city precludes any convincing hand-drawn reconstruction unless the illustration covers several square meters of paper.

With the help of the digital media, one could hope to produce a more visually convincing and accurate reconstruction of the city. Parts of the city could be modelled separately and then assembled to form the whole. Such images help render the awesome scale and cityscape of the Tang capital, once imagined only in the minds of scholars and

researchers, accessible to the layperson. Walkthroughs of the model could be simulated. With enough computational power, simulating the urban environment in virtual reality in real time virtually transports the viewer to the city, providing him with the possibility of experiencing and understanding the historical urban landscape. However the experience is only as accurate or as good as the model itself and therein lies the difficulties.

2.1.2   Methodology

There are several different kinds of difficulties involved in reconstructing and modelling Changan. First of all there is the problem of accuracy. This inevitably involves the availability of source materials. These may be classified under the following headings: textual, pictorial, and physical. While there are a number of primary and historical textual documents that provide important information relating to the dimensions of the walls, roads, wards and vegetation, as well as the contents of the wards, these fail to inform us of specific formal aspects of the city[3].

Primary pictorial sources are just as problematic. These are also limited in numbers and are confined mainly to the Dunhuang mural paintings, occasional stone engravings, and paintings. These pictorial sources though not directly relevant to the capital Changan nevertheless help us to understand the nature of Tang architectural and urban landscapes. Although the verisimilitude of the Tang period murals is subject to contention, we have to depend partly on them to supplement our knowledge of Tang architecture, layout, and building types. However as scholars have pointed out, these depictions were often Oconventional repetition of specific symbolic forms to represent various buildings and landscape elements or shorthand rendition(s)[4]. We are hence caught in a dilemma in which we have to make subjective judgements of what to use and what not to use for our reconstruction of Changan's cityscape.

In terms of primary physical sources, archaeological findings and reports are extremely useful. Besides confirming the information culled from literary sources, they provide useful information on roads, drains, city walls and gates, and even the layout of certain buildings and architectural details and construction. Funerary pottery models of houses and extant Tang architectural relics in China and their counterparts in Nara and Heian, Japan, also provide critical information on the formal aspects of Tang architecture. Finally modern reconstructions of Tang architecture by notable architectural historians are also useful sources of reference[5].

However there is yet another level of difficulty involved in the reconstruction of the urban components. While recreating individual buildings poses a challenge, it is relatively manageable in that the sources cited above provide us with a sufficient understanding of Tang architecture to model buildings that look "Tang-like". On the other hand, where the layout of Tang building complexes is concerned, there is little to depend on. Certainly for Buddhist architecture, there are examples of extensive building complexes in the Pure Land paintings in the Dunhuang murals. However, as mentioned earlier, the credibility of these layouts depicted is still subject to debate. We could also consult contemporary religious complexes in Korea and Japan. Early Chinese Buddhist temples, according to some scholars, were "faithfully copied in Korea" although later Korean designs beginning in the sixth or early seventh century began to exhibit local characteristics [6]. However as there were no examples of Chinese temple layout from the Tang period, reference to Korean and Japanese examples is necessary. These same difficulties are also encountered in the reconstruction of Tang domestic and commercial architecture.

At yet another level, determining the layout of the walled wards is also problematic. Simple calculation yields an average of 2400 households or residential compounds per square kilometer of ward space.[7]. However taking into consideration differences in population distribution within the city, some wards were certainly more densely populated. The density was probably highest in the East and West markets and in the wards around them. [8]. While theoretically the larger wards were divided into quarters and further subdivided into sixteen smaller neighbourhoods, large religious compounds or even aristocratic residences in the wards disrupt this pattern. The arrangement of houses, temple complexes and large mansions within each ward is also unknown. The only clues are the locations of important residences and religious establishments along the edges of the ward and the fact that the compounds were most probably oriented north-south. If this was the case, then there were certainly more lateral

alleys in the wards than longitudinal ones. This theory is substantiated by the layout of the Imperial City.

Another problem encountered in our reconstruction is the precise period of city chosen for the reconstruction. Although generally termed as Tang period Changan, the war-ravaged Changan of the late 9th century did not have the same cityscape it had at the height of its glory just before the An Lushan rebellion [9]. Our reconstruction cannot hope to recreate the city at any specific point in time as there is not enough information on the city let alone the city at a particular point in time. What is attempted here is a generic view of what the city could have been with its monuments, official buildings, vernacular structures, and walls intact.

Besides the problems of accuracy, the high density and large number of residential compounds of the capital also pose difficulties at the technical level. The software Microstation Version 5.0 was selected for modelling the urban components on INTERGRAPH UNIX workstations. Rendering and animation was done using Modelview. After a preliminary study in which a section of the city was modelled in detail, it was soon evident that the size of the city and the number of components preclude modelling the entire city consistently in detail. If the level of resolution chosen for modelling the city is high, the computer used will not be able to provide the enormous amount of computer memory necessary for the large number of details or will be excessively bogged down by the size of the files to make the model useful. On the other hand, a model of too low a resolution will be too schematic to be of much use.

2.1.3   City Level

It was finally decided that urban components should be constructed at three different levels of resolution. At the city level, simple massing models of individual urban components were created and later combined to form wards (Fig. 1). These wards when multiplied and combined produce a model of Changan that shows texture and grain when seen from an elevated view point (Fig 2). Essentially the intention of such a model is to illustrate the basic scale of the city and its urban structure and organisation. The size of the city however makes the vertical variations in height almost imperceptible when seen in relation to the horizontal dimensions. Therefore it is necessary to exaggerate the vertical dimension so as to make the height of the city more significant than it really was.
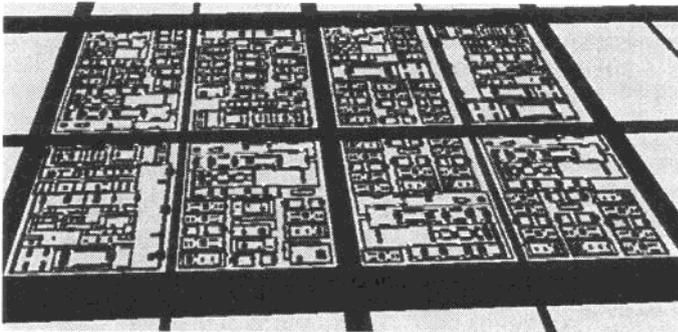

Figure 1. Simple massing models used to form

Figure 2. Combination of a few wards showing density and texture

2.1.4   Compound Level

It was also decided that certain urban components and buildings in the city should be rendered in detail. Such elements include city walls, selected city gates, ward walls,

ward gates, selected temples, towers, houses, bridges, and the like. These elements were chosen for various reasons. They were either significant urban elements such as the main city gate, Mingde Gate, landmarks such as the Big Wild Goose Pagoda *(Dayan ta)* or the ever present ward gates (Figs. 3 and 4). Rendering these examples in detail allows us to design OwalkthroughsO in the model in order to experience the cityscape up close and to appreciate the splendour and monumentality of some of the urban and architectural elements and to provide a sense of realism to the visual experience.
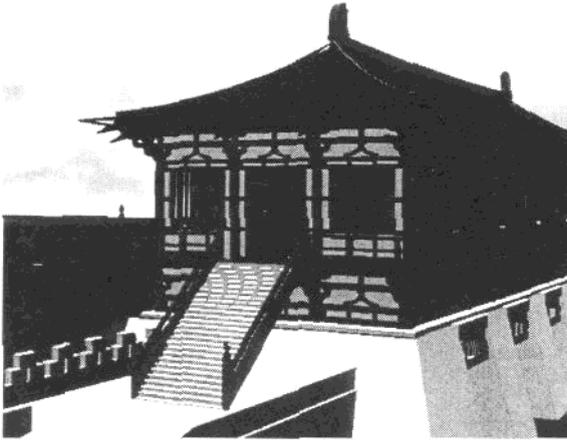

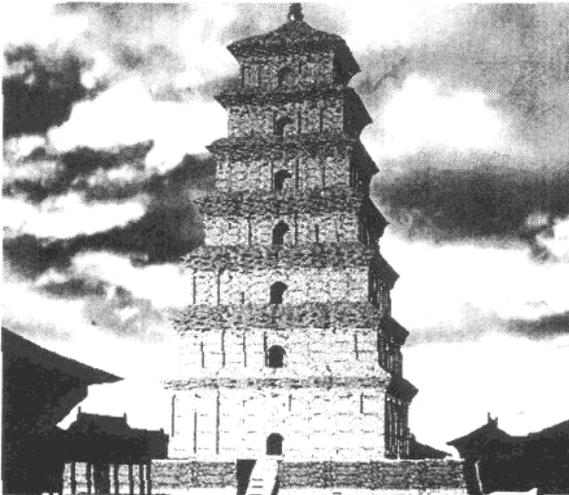Figure 3. Reconstruction of Mingde Gate, the city`s main gate

Figure 4. Reconstruction of Big Wild Goose pagoda *(Dayan ta)*

2.1.5   Ward Level

A third kind of model was also constructed of the range of building types mentioned above. They were constructed at an intermediate level of resolution somewhat between the first and the second kind. For each building type, a wide range of variation was made (Fig. 5). These models are geometrical abstractions of the buildings and provide sufficient details for the recognition of architectural styles, significant details and, of

course, building forms. When completed, the individual components were then used to form wards of different natures and population densities. They help us visualise the structure and organisation of the wards and also provide the urbanscape with a sense of massing of the urban fabric, scale and texture of buildings and urban spaces, nature of skyline and the appearance of open spaces (Fig. 6). These models also have the advantage of being relatively economical in computer memory and could be usable for real time animation.
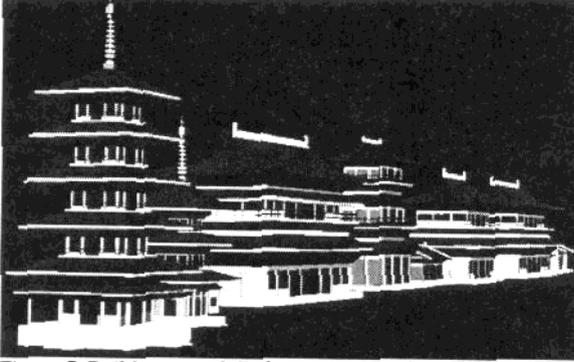

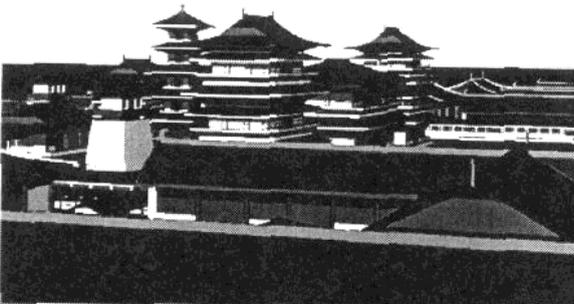
Figure 5. Buildings modelled at an intermediate resolution

Figure 6. Buildings combined to form a temple compound

2.2   Suzhou

Suzhou was a prefectural capital and one of the foremost cities in Song period China. Although the city was sacked and torched by the invading Jin forces in 1130, it underwent a major facelift during the first quarter of the thirteenth century and quickly regained its original splendour. Unlike Changan, the city was not built to the scale of the empire. Instead the city's circuit wall defined a roughly rectangular enclosing an area of slightly more than 14 km^2. The city was far smaller than Changan.

Within the wall, slightly south of the centre was a large fortified administrative compound served by two gates. This was the administrative heart of the city and the prefecture. Outside the compound, the city was served by a complex water transportation network of six major N-S and 14 E-W canals. This network is paralleled by an equally subtle system of bridges and streets animated by T-junctions and cranked intersections. Unlike Tang Changan where walled wards filled up the city, Song Suzhou was a city active with street life.

An important map, Pingjiang tu, engraved on a stone tablet, 1.98 m by 1.34 m, faithfully records the important urban structure and major features of the city. This map

was carefully sculpted in 1228 to commemorate the renovation of the city. The map shows a city based on a supple orthogonal pattern of roads and canals interspersed with occasional oblique and curvilinear streets and waterways at the periphery. Important junctions were marked by street-straddling portals carrying the names of the neighborhoods. Except for some walled rectangles enclosing administrative centers, official buildings, religious edifices, and the like, the map shows numerous street front edifices underlining the evolution of a ward-centred city as was the case in Changan to a streetcentred one. The entertainment spots and some 308 bridges depicted also indicate - by their names - where several commercial districts lay in the city. However the city did not only changed on a formal basis, the kind of urban life and experience were also different. Unlike the Tang capital where trade was restricted to specific locations and times of the day, night life blossomed in Suzhou and commercial activities flourished.

Song Suzhou represents a new paradigm in the development of Chinese cities. While Changan epitomized the mature state of the Chinese medieval city with a long history behind it, Suzhou represented the infancy of a new urban structure and a prototype to a long line of descendants until the advent of modern industries, technologies, and government in the course of the last two centuries gave rise to new urban forms and landscapes. It is in this context that the modelling of Song period Suzhou is both informative and meaningful.

2.2.1   Methodolgy

As in the case of Tang Changan, the reconstruction of Song period Suzhou depends heavily on textual, pictorial and physical source materials. Being more recent in history and with the flourishing of the press in Song China, there were comparatively more =ion sources. These ranged from monographs on the city such as *Wujun zhi* to information culled from miscellaneous notes [10]. Unfortunately, these textual sources once again failed to inform us of the specific formal aspects of the city. They could however confirmed the accuracy of the stone map and provide supplementary information on installations not depicted on *Pingjiang tu*.

We are far more fortunate when it comes to pictorial sources. First of all, the stone map *Pingjiang tu* provides us with ample information on the specific locations of a number of different establishments within the city. It also clearly marked out the road and canal system that structured the city. With a map of this nature and accuracy, the reconstruction of the city is made more credible [11]. Another pictorial source is the early twelfth century painting of a busy urban scene entitled *Qingming shanghe tu* or Going up the River during the Qingming Festival. This highly detailed painting provides us with a wealth of visual information that would fill volumes of description [12]. Although the styles of architecture in the northern areas may be substantially different from those of water-based Suzhou, the painting still serves as a reference for Song period cityscapes. Besides this masterpiece, there are several dozens of other paintings from the Song period that provides information on the Song architecture[13]. We are therefore able to have a good understanding of both Song architecture and streetscape.

In terms of physical sources, there are still a number of buildings in Suzhou dating from the Song period. Notable ones are the pagodas *Beisi ta*, *Shuang ta*, *Ruiguang ta* as we as the temple *Tienqing guan*. Although the city has changed substantially, its basic urban structure still conforms largely to that shown in Pingjiang tu. In fact there is a study by Frederick Mote in which he shows the extraordinary stability of the urban structure of Suzhou [14]. One could overlay the urban structure of Song period Suzhou as depicted in *Pingjiang tu* over the modem day Suzhou and find general correspondence throughout most of the city.

The reconstruction of Song period Suzhou therefore presents difficulties of different dimensions from that of Changan. While primary sources and extant physical structures provides us with adequate information to reconstruct the urban structure as well as locate major facilities, establishments, and landmarks within the city, these same sources are not very specific about the architecture of the urban common folks. They are also not very informative on the layout of the architectural compounds indicated either textually or pictorially. There is therefore still a substantial gap left for interpretation.

2.2.2   3D Modelling

The first task involves creating the urban structure of Song Suzhou based on the comparison of Pingjiang tu and the map of modern Suzhou [15].This is a relatively easy task save for the determination of the widths of roads and canals and the determination of a certain hierarchy within the transportation networks (Fig. 7). The distortion in scale, not apparent in the stone map, is immediately evident upon comparison of the two maps.
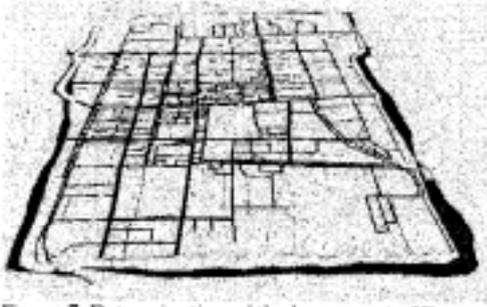

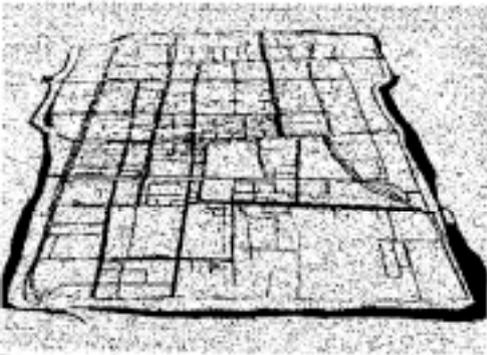Figure 7. Determination of the base map in 3D

Figure 8. Inclusion of buildings culled refences in literary sources

Over the reconstructed city structure is then overlaid the 3D structures depicted in the Song map. While establishing the locations of these installations pose little difficulty, determining the layout of the architectural compounds was far more tentative. An understanding of Song period architecture helps to inform personal interpretation and decisions concerning their layout. References culled from primary literary sources about buildings not shown in the stone map are then added to the 3D urban model (Fig. 8). The two sets (those from *Pingjiang tu* and those from literary references) are then combined to form a fairly accurate base of the city insofar as the urban structure and locations of Song period buildings are concerned. All these architectural compounds are modelled at an intermediate level of resolution as in the case of the compound level models of Tang Changan (Fig. 10). These models, though in abstracted form, are sufficiently detailed to show architectural styles and to provide the urbanscape with a sense of massing as well as the nature of the urban fabric, scale, and texture of buildings. Urban spaces, nature of skyline, and the appearance of open spaces are also sufficiently portrayed by these models (Fig. 12 and 13). Models of this level of resolution are also built because of their relatively economy in computer memory. Again, these models could eventually be used for real time animation. For the government enclosure depicted in the Song period map, an attempt was made to reconstruct the layout and the architecture based on the formal principles of this genre of architecture[16].

Figure 9. Tentative reconstruction of quarter north of the government enclosure

Figure 10. An abstracted model of an extant Song period pagoda

Finally, the residential quarter immediately north of the government enclosure was selected for a trial reconstruction in order to portray the cityscape of Song Suzhou (Figs. 9 & 12). Residential and commercial buildings were modelled and combined to form an urban scene not unlike those portrayed in Song period paintings such as *Qingming Shanhe tu* or *Lady Wenji's Return to China*. With the completion of this section of the city, earlier decisions taken while modelling the city could be re-evaluated and amended if necessary. Upon visual analysis and deductions, certain street widths, for instance, were reduced. the juxtaposition of the government enclosure and the district north of it, one could easily contrast the informality of the street scene with the formal layout of the prefectural administrative centre (Figs. 13 and 11).

Figure 11. Reconstruction of streetscape in quarter north of the government enclosure
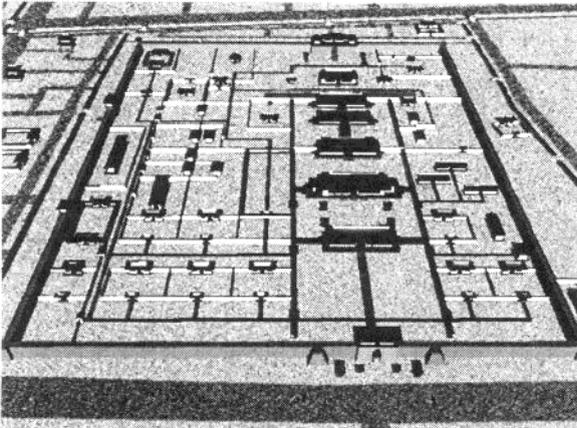

Figure 12. Reconstruction of the government enclosure

Figure 13. Reconstruction of a streetscape

3   Conclusion

The use of digital modelling helps enormously in the perception of built environments. This is particularly important in the simulation of proposed project or, as illustrated in the two cases of Chang an and Suzhou, the visualisation of lost historical built environments. These 3D models narrow substantially the knowledge gap between the expert and the layperson and allows the latter to partake in the evaluation and analysis of built environments. While textual sources describe the severe nature of the Tang cityscape, the phenomenal scale of the Tang capital, and the relative informal nature of the Song cities, these differences becomes immediately apparent in the 3D reconstructions of these urban prototypes. The next step in an exercise of this nature will be to go beyond using the 3D descriptive model as a tool of formal analysis and visualisation and extend its use to other forms of analytical study, perhaps by coupling it to databases.

4   Endnotes

[1] E. H. Schafer, "The Last Days of Ch'ang-an", *Oriens Extremus, 10* (1963), pp. 137-79 (p. 157).

[2] Two of these wards were later subdivided when a new road was laid to provide access to a new palace, Daming Gong, built in 634. The number of wards was then increased to 110. During the reign of Tang Xuanzong, a new palace, Xingqing Gong, was built on one of the wards, hence reducing the number of residential wards to 109.

[3] Textual material used includes among others, Song period *Chang 'an zhi* and the later Qing work *Tang* hang *chengfang kao* as well as *Tang huiyao* and in *Jut Tangshu* (in particular *Dilizhi), Sita ji* by Duan Chengshi and the Japanese monk Ennin's diary.

[4] Ernesta Marchand, OThe Panorama of Wu-T'ai Shan as an Example of TenthCentury Cartography, *Oriental Art,* Summer 1976, Vol XXII No 2, pp. 158-173.

[5] Architectural historians such as Fu Xinian, Yang Hongxun, and the late Liang Sicheng.

[6] Kim Sung Woo, *History and Design of the Early Buddhist Architecture in Korea* (Ph.D. dissertation, University of Michigan, 1985) p. 472.

7[7] At its peak, Chang'an had about a million inhabitants within its 84 or so square kilometers or an average of around 12000 inhabitants per square kilometer. With an average of 5 persons to a household, there would have been about 2400 households or residential compounds of different sizes in one square kilometer of ward space.

[8] There were so many shops in the East Market, for instance, that according to the Japanese pilgrim Ennin, some four thousand shops in twelve streets *(hang)* were destroyed in a single fire that broke out at midnight on the 27th day of the sixth moon in 843. See Reischauer, Ennin 's *Diary, p.* 333; see also Kato Shigeshi, "On the Hang or the Associations of Merchants in China, with Especial Reference to the Institution in the T'ang and Sung Periods" in *Memoirs of the Research Department of the Toyo Bunko,* No 8, Tokyo: The Toyo Bunko, 1936, p. 50; see also Wang Pu (922-982) ed., *Tang Huiyao* [Important Documents of the Tang Period], (Shanghai: Shanghai guji chubanshe, 1991), c. 44, p. 923.

[9] See E. H. Schafer, "The Last Days of Ch´ang-an", *Oriens Extremus, 10* (1963), pp. 137-79.

[10] Fan Chengda (1126-1193), *Wujun zhi* [Record of Wu Prefecture].

[11] See Du Yu, "Cong Song 'Pingjiang tu' kang Pingjiangfu de guimo he buju" [Observing the Scale and Layout of Pingjiang Prefectural Seat from *Ping Jiang Tu*], *Studies in the History of Natural Sciences,* Vol. 8 No. 1(1989), pp. 90-96.

[12] Although there is some debate regarding city depicted, most scholars agree it is Bianjing (modern Kaifen). See Yu Song, *"Qingming shanghe tit suo* hui wei Bianjing fengwu shuo" [That the Subject Depicted in *Going Up the River during Qingming Festival is Bianjing], Henan daxue xuebao* [Henan University Journal] , 1988/1, pp. 1-5.

[13] One other important painting is an eleventh century painting entitled *Lady Wenji's Return to China* in which a section of a street with its multifarious activities is shown in front of an aristocratic residence.

[14] F.W. Mote, *A millenium of Chinese urban history: form, time, and space concepts in Soochow,* in Rice University Studies 59, no. 4 (1974). See also Heng Chye Kiang, "Unraveling Urban Layers for Informed Urban Interventions." In Proceedings of 6th

Annual Conference of Pacific Rim Council on Urban Development, Taipei, Nov 1-3,1994, pp. 366-373.

[15] See Heng Chye Kiang, Unraveling Urban Layers,O pp. 368-373.

[16] See R. Stewart Johnston, *Scholar Gardens of China,* Cambridge: Cambridge University Press, 1991, pp. 26-30 for an alternate interpretation on the layout of the enclosure.