A Reconstruction of the Ancient City of Ayutthaya Using Modern Photogrammetric Techniques

Cliff Ogleby
Department of Geomatics
The University of Melbourne
Parkville, 3052, Australia
Telephone: 61 3 9344 6808, Facsimile: 61 3 9347 2916
c.ogleby@engineering.unimelb.edu.au

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Abstract

The architectural and archaeological heritage of the world is under increasing threat of destruction in the latter part of the 20th Century. Recent hostilities around the world have shown the fragile state of civilisation's monuments, and increasing pressure from rising population and human mobility threatens sites in even remote locations like the Australian desert. For many years now photogrammetry has played a significant role in documenting this heritage, and many recent advances in the technique have enhanced the use of photogrammetry as a recording technique.

The University of Melbourne has had a long involvement with Chulalongkorn University in Bangkok Thailand, and with implementing photogrammetric recording programs in Thailand. Recently, the University was awarded funding to support a program to create a computer visualisation of the ancient capital of Ayutthaya. This project will blend 3D CAD models of the architectural features of Ayutthaya with historical research and artistic rendering to build a realistic representation of this city.

The model of the city has been built up from the base map created from small format photography and other sources (with the modern town 'removed'), and the use of architectural photogrammetry to derive models on individual *wat, chedi* and *prangs*. The historical research conducted in Thailand has provided the basis for the determination of the most likely location of the structures. The various 3D models have been exported to Wavefront Advanced Visualiser, a fully featured animation software package operating on an SGI Crimson computer. Real surface textures and materials were derived from the original photography, ensuring that the model best represents the real situation.

The end product, when completed in 1997, will be capable of producing animations of daily life in Ayutthaya, with the potential for giving an interactive experience depending on the level of computer technology employed in the visualisation. The reconstruction will also be used as the basis of a variety of educational products to be produced in Thailand on a variety of media, including CD-ROM.

1. INTRODUCTION

Ayutthaya is a modern city of around 60,000 population, some 80km from Bangkok in Thailand. It has also just recently become a World Heritage Site, as it was the capital of the Kingdom of Siam for around 400 years up until 1767AD, and in its day one of the most spectacular cities anywhere. The location of Ayutthaya is shown in Figure 1.

The University of Melbourne in Australia, and Chulalongkorn University in Thailand are conducting a three year research project to re-create the greatness of Ayutthaya in the form of a photo-realistic, three-dimensional computer model. In order to achieve this, detailed photogrammetric records of the remaining architectural monuments will be combined with early written records of the city and the assistance and expertise of the Royal Thai Government Fine Arts Department. The basis for the creation of the CAD models is, however, the photogrammetric record.

The model resulting from the research will then form the basis of a series of 'visualisations' and animations of the city, and these will be produced into a video that will re-create life in Ayutthaya in the 1600s. The material will also be produced into a CD-ROM so that it can be used throughout Thailand as an educational resource.

At the moment the project is in the initial stages, at the time of writing this paper few visualisations had been created apart from those used to verify the feasibility of the methodology. It is envisaged that considerably more progress will be presented at the XVIII ISPRS Congress.

The dates used in this paper are those based on the Christian era, the Thai Buddhist dates can be obtained by subtracting 543 years.

2. A BRIEF HISTORY OF SIAM, THAILAND AND AYUTTHAYA

The human settlement of what is now known as Thailand has been found to go back some 5000 years, although like all statements derived from the archaeological record new discoveries may change this. It is thought that the 'Thai' people migrated southwards from the southern provinces of China over a long period of time, following the river valleys across the Indo-Chinese Peninsula. This was often a forced migration as a result of internal and external strife between the provinces in China. The Menam region (Central Thailand around the Menam River) was ruled by a variety of dynasties over the centuries, including long time adversaries the Burmese and the Khmer. The Khmer rulers gained precedence for a time, eventually establishing the seat of their northern regional governor at Sukhothai (another World Heritage Site) around 1150±. The Khmer domination of this city ended under the concerted efforts of smaller states, establishing what became known as the 'Pra Ruang' dynasty (the first 'Thai' dynasty). The rulers of this dynasty extended the borders of their conquests as far as the Malay Peninsula, whilst inheriting much of the arts and cultures of the defeated Khmers.

A national language was devised at Sukhothai around 1283, based on Mon and Khmer scripts, which had their origins in Southern India. The development of a common language helped strengthen the increasing national identity of the 'Thai' people, and this script is still in use today (albeit with some changes). In addition, Thai Buddhism (Theravada) became codified during the same period, and the age of the Sukhothai kingdom is often viewed as one of the golden periods in Thai history. The borders of the new Sukhothai swelled and contracted as a result of the various battles fought between principalities, but eventually the region came under the governance of the southern kingdom of Ayutthaya in the reign of Maha Tammaraja II (1370±), ending the city's 140 years of independence and the Sukhothai monarchy.

Figure 1: Map of Siam, from De La Loubere.

Ayutthaya was a well established town before it became the capital of Siam, supposedly it was founded by a Prince of Ut'ong (U-Thong) in the year 1350 or 51. Or, more to the point: ... *So he had his troops cross over and establish themselves on Dong Sano Island.... In 712, a Year of the Tiger, second of the decade, on Friday, the sixth day of the waxing moon of the fifth month, at three nalika and nine bat after the break of dawn, the Capital City of Ayutthaya was first established* [i.e., Friday March 4th 1351, shortly after nine o'clock in the morning] (Wyatt 1984, translation from Cushman). It is named after *Ayodhaya*, the home of Rama in the *Ramayana* epic, which means 'unassailable' or 'undefeatable' in Sanskrit. It is set on an island

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situated at the confluence of three rivers; the Chao Phrya (Menam), the Lopburi and the Pasak. Under King Ramatibodi's (P'ya U-Thong) reign the state began to be ruled as an absolute monarchy much the same as Sukhothai. The region was strong and increasing in strength during the 14th, and 15th centuries. The kingdom had developed an administrative system with Great Officers to help rule, and gave these people power through the establishment of proclaimed laws and punishments for breaches. The state of Ayutthaya extended its boundaries in the customary manner, by fighting battles with neighbouring dominions and provinces like Chiang Mai, Chiang Rai, Cambodia (Angor Wat and Angor Tom), Molucca, Burma (Myanmar) and so on. The favours were often returned, especially by the troublesome Chiang Mai and Burma.

Ayutthaya became one of the wealthiest and greatest cities in Asia, and attracted the interest and awe of Europe. In the 16th century, visitors from Europe were arriving in Thailand, for trade in both goods and Christianity. Visitors, traders and missionaries from Portugal arrived around 1511, from Japan around 1690, from Holland around 1605, England around 1612, Denmark around 1621 and France in 1662. Many of these foreign missions were allowed to settle as 'embassies' and it is from many of these travellers that the historical details of Ayutthaya can be discovered. The glory of the city was reported widely in Europe, and most visitors claimed it to be the most splendid city they had seen.

For example: ...We never saw a Fabrick no not in France, where Symmetry is better observed, either for the body of the Building, or the Ornaments about it, than in this Pagod. The Cloister of it is flancked on the outside on each hand with sixteen great solid Piramids, rounded at the top in form of a Dome, above fourty foot high, and above twelve foot square, placed in a Line like a row of great Pillars, in the middle whereof there are larger niches filled with gilt Pagods. We were so long taken up with the sight of these things that we had not time to consider several other Temples close by the Post within the same compass of Walls (Guy Tachard, 1688, in Smithies, 1995).

In time, the Burmese once again conquered the Kingdom of Ayutthaya, this time burning the city to the ground in 1767 following two years of battle. Ayutthaya did not rise again, and the capital of Siam moved to Bangkok. As a result, all that really remains of the greatness of Ayutthaya are the chedis, prangs and defaced statues of the temples; all of the timber buildings, the palaces and the houses are gone. In addition, apart from a few selected areas, modern Ayutthaya infects the historical city with roads, shops, houses, condominiums, cars, trucks, dust, mud and exhaust fumes.

3. THE PROJECT

The aim of the overall project is to create, as realistically as possible, a three dimensional computer based model of the Ancient City of Ayutthaya as a foundation for an animated visualisation of life in the City some 300 years ago. This will incorporate architectural models of buildings, structures and decorations, models of trees, models of animals and people, models of boats and carts, and so on. Much of this can be provided by adopting the technique of photogrammetry to record the existing architectural features, but other data sources are also required. The visualisation will also incorporate live video sources of traditional dance and music, and sounds of life typical to the period.

This may appear to be out of the domain of the traditional heritage photogrammetric recording program, but in this case it is an essential part of the 'cultural record'. Here the photogrammetry is the tool required to achieve the desired end product, it is not used for its own sake.

In general, the project will involve:
- the creation of CAD models of existing cultural monuments using photogrammetry as the basis;
- investigation of early travellers reports as to the form and decoration of the missing monuments;
- reconstruction in the computer of the missing architecture;
- recreation of the other attributes of Ayutthaya like the canals, the elephants, the barges and carts;
- sampling sound and video for use in video production and post-production;
- compilation of the animations into a video-based product; and
- development of an interactive computer based Ayutthaya experience.

4. THE PHOTOGRAMMETRIC RECORDING PROCESS

In order to create the 'virtual' reconstruction of the city, there needed to be a starting point from which to venture. Because of the well established three dimensional recording possibilities offered by photogrammetry (Ogleby

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1995,) it was an obvious choice as a tool to create the initial models of the main remaining architectural elements. In addition, because of the initial lack of a suitable base map, small format aerial photography was also planned as the method offered the possibility for creating three-dimensional maps to a sufficient accuracy (Fraser et al, 1995).

4.1 Architectural Recording

The technique employed at Ayutthaya is relatively straight forward, and based on (but not limited to) the proven case of the terrestrial stereo-pair. In general, stereo-pairs were taken of the façades of selected chedis, prangs, stele and walls so that a 'library' of architectural elements could be derived. Convergent photographs were also taken of many of the features so as to have the possibility of strengthening the control network for the features if necessary. The camera used was a Hasselblad 500ELM with a reséau plate, and either a 50mm lens or an 80mm lens as required by the geometry. The camera was mounted on a good quality, stable, Manfrotto brand tripod, allowing the camera orientation to be repeated between exposure stations to an accuracy suitable for the restitution of the stereo-pairs. The film used was Fujichrome 100 ASA colour transparency, giving good colour saturation with medium archival qualities.

Figure 2: Wat Kung Sang, a chedi in poor condition

It is important to acknowledge that the photogrammetric recording procedure was designed for the purpose of creating the basic three dimensional models needed for the computer reconstruction. This was not a documentation program, although the records can be used in part for this purpose. Rarely were all the sides of a chedi recorded, a minimum number of elevations or façades were photographed as nearly all of the architectural features were symmetrical. Poor or badly preserved examples (Figure 2) of a particular chedi or prang style were not recorded, the photographs would not be of much use in the derivation of a three dimensional 'cell' of the object. There was neither the time, the funding nor the immediate level of interest in establishing a significant documentation program as part of this project.

Numbered targets were placed on the surface of the features being photographed, and coordinates derived for each of these. The targets are made from 5cm square aluminium covered with a self-adhesive cross target produced some years back for a theodolite intersection exercise in the aerospace industry. The targets are numbered and placed on the feature using re-useable adhesive similar to the 'BluTac' product, allowing the targets to be removed once the photography is completed. In general, six such targets are placed for each stereo-pair as experience has shown the extra time taken to coordinate targets in the field is considerably less than that required to extend weak control networks across architectural features using either triangulation or bundle adjustment of pass points. Where the size or height of the object did not facilitate the placement of targets at key locations, features on the surface of the building were used as photo-control points. Their location was described and sketched so they could be recognised back in Australia.

Three dimensional coordinates for the targets was provided by theodolite radiation from either an arbitrary control point, or an instrument point coordinated as part of a network. A network of controlled instrument points were placed around the main chedi area of Wat Pra Si Sampet (the most recognisable remains at Ayutthaya), and coordinated onto the Thai mapping grid using a Leica System 300 GPS as part of the preparation for the aerial photography. This provides for the actual spatial location of the eight features recorded to be determined. At other locations a local coordinate datum was used as only the shape and size of the feature was required, its true position could be determined by other means if necessary.

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The theodolite radiation was undertaken using a Leica T2000 combined with a Leica reflectorless EDM. This meant that distances could be obtained o the targets without the requirement to use either glass prisms of retro-target tape. The EDM performed very well, however on occasion it was necessary to acquire multiple distance readings along a vertical profile near an element or target to ensure that the distance measured was actually to the required feature. The EDM would return a signal from a diverse range of surfaces, including the odd Japanese tourist on line, branches of trees, and, as a result of the vertical offset between the telescope of the theodolite and the EDM, any other point on the surface of the walls as well as the target. Once the procedure had been perfected the coordination of the targets was straight forward. The offset correction was accommodated for during the data reduction.

4.2 Aerial Photogrammetry

Initially it was intended to acquire aerial photography over the main area of interest at Ayutthaya, and indeed up until it proved too difficult to obtain the necessary permissions this was to be the case. The fortuitous discovery of the large scale maps of the Historic City Area meant that the need for the aerial photography was not as desperate, but still desirable. This may be obtained on future visits, as all of the preparatory work has been undertaken.

The advent of differential GPS positioning means that the otherwise arduous task of providing control for aerial photogrammetry is now simple (if expensive). The Thai partner Department at Chulalongkorn University owns, as does the University of Melbourne, a Leica System 200 GPS set of units. These were used at Ayutthaya to coordinate features that would be visible in the aerial photographs, as well as the occasional instrument station. This was undertaken by establishing a base-line between a survey control point located 4km from the main area of interest, and a new point established in the old palace region of Wat Pra Si Sampet. A receiver was left at each of these two points, and the third taken to each of the photo-control points. A set-up time of around 10 minutes at each point was sufficient to give an accuracy suitable for aerial mapping and topographic surveying. Following processing through the SKI software package a precision of around 0.01m was obtained for all the points visited, the whole process taking about one and a half days.

4. SOURCES OF TOPOGRAPHIC INFORMATION

Information regarding the topography of ancient Ayutthaya is difficult to determine, it can only be based on the modern topography and interpretation of the historical record. The region around the main Palace area, which is the subject of the current project, is basically flat with the occasional pond and lake. The elevation of the region is barely 4m above sea level, the sea being some 100 kilometres down river. The main topographic features are the rivers and the lakes, there is very little relief in the region. According to the historical maps, there were considerably more canals during the historic period than are present today. It was then necessary to modify the terrain model in order to accommodate these missing structures. The early maps published by the European visitors to Ayutthaya vary in scale, shape and level of detail, so they are subject to some interpretation regarding the true position of features they show.
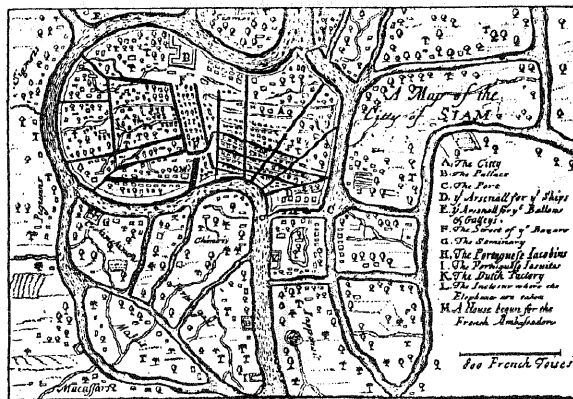

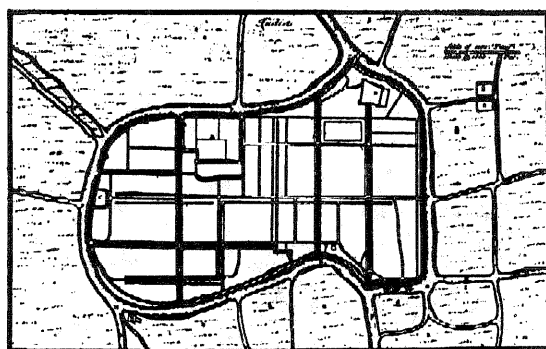Figure 3. Map of Ayutthaya, from De La Loubere, 1688

Figure 4 Map of Ayutthaya, from Kaempfer, 1727

The information regarding the modern topography was acquired from existing maps, with the occasional field survey to augment the data. As mentioned above, it was planned to acquire small format aerial photography

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specifically for the preparation of a digital terrain model however this was not possible during the field visit (it is very difficult for civilians to acquire aerial photography in Thailand).

It was quite fortuitous that recent mapping performed as part of the Department of Fine Arts Reconstruction Project became available for use as it showed contours of 1m interval over the project region. This contour information was used to create line strings at the appropriate height in the CAD files, and these were then converted to a digital terrain model using Intergraph's MSM software.

5. SOURCES OF ARCHITECTURAL INFORMATION

There are several very different sources of information regarding the architecture of the historical city. These are as diverse as the photogrammetric record of existing structures acquired for this project; the drawings made by European visitors of the time; the written descriptions of the city and a variety of other 'reconstructions' including scaled models. This project has attempted to successfully combine these into a feasible and accurate vision of the precinct around the Late Ayutthaya Period.

Luckily for the researchers in the project of a non-Thai speaking background, there are a variety of published references to the architecture, customs, peoples and history of Siam around the period of interest to this project. There were reports published in French that became so popular they were translated into English, along with other reports in English, Dutch and Japanese. These provide an excellent source of information regarding the appearance of the buildings in the city, many of which have disappeared over the centuries.
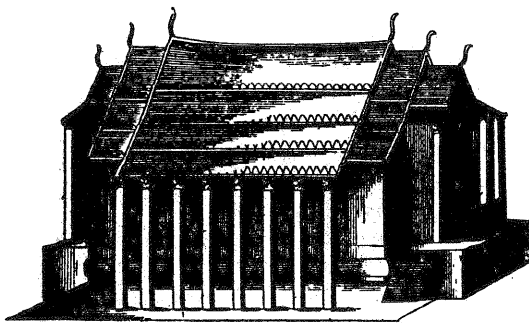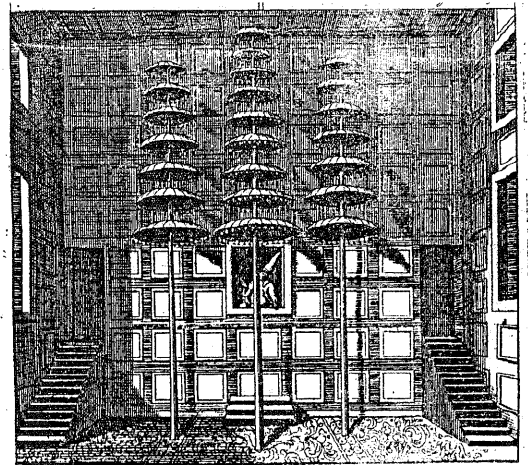

Figure 6: A palace, Ayutthaya. From Kaempher 1727

A Prospect of the Hall of Audience in the Palace of Siam.

Figure 5: The Audience Hall, Ayutthaya. From Kaempher 1727

See for example Figures 5, 6 and 7. Take also for example, the following passage:

About an hundred paces South of the Palace there is a great Park walled in, in the middle whereof stands a vast and high Fabric built cross-ways in the manner of our Churches, having over it five solid gilt domes of Stone or Brick, and of extraordinary Architecture, the dome in the middle is far bigger than the rest, which are on the extremities and at the ends of the Cross. This Building rests upon several Bases or Pedistals, which are raised one over another, tapering and growing narrower towards the top. The way up to it on the four sides is only by narrow and steep Stairs of betwixt thirty and forty steps three hands broad apiece and all covered with gilt Calin or Tin like the Roof. The bottom of the great Stair-case is adorned on both sides, with above twenty Statues bigger than the Life, some whereof are of Brass, and the rest of Calin and all gilt, but representing but sorrily the Persons and Animals for whom they have been made. This great Pile of Building is encompassed with forty four great Piramides of different form and well wrought, ranked orderly upon different Plat-forms. On the lowest Plat-form stand. the four greatest at the four corners of it upon large bases. These Piramides end at the top in a long very slender Cone, extremely well gilt, and supporting a Needle or Arrow of Iron, that pierces through several Christal balls of an unequal bigness. The body of those great Piramides as well as of the rest, is of a kind of Architecture that comes pretty near ours; but it has too much Sculpture upon it, and wanting both the simplicity and proportions of ours, it comes short of its beauty, at least in the eyes of those that are not accustomed to it. If we have time we may give a more perfect Idea of that

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Architecture upon the second Plat-form, which is a little above the first, there are six and thirty other Piramides some what less than the former: making a square round the Pagod, nine on each side. They are of two different Figures, some taper into a point as the former did, and the rest are made round like a Bell on the top, after the manner of the domes which crown the Building; they are so mingled that there are not two together of the same form. Over these in the third Plat-form, are other four Piramides on the four corners of it, which terminate in a point. They are less indeed than the first, but bigger than the second. All the Fabrick and Pitamides are inclosed in a kind of square Cloyster, above six-score common paces in length, about an hundred in breadth, and fifteen foot high. All the Galleries of the Cloyster are open towards the Pagod; the Cieling thereof is not ugly; for it is all painted and gilt after the Moresko way. Within the Galleries along the out Wall which is all close ranges along Pedestal breast high, on which stand above four hundred Statues, rarely well gilt, and placed in most excellent order. Though they be only of Brick gilt, yet they appear to be very well shaped, but they are so like one another, that if they were not unequal in bigness, one would think that they had been all cast in the same Mould. Amongst these Figures we reckoned twelve of a Gigantick Stature, one in the middle of each Gallery, and two at each Angle. These Figures, because of their height are fitting upon fiat bases cross-leg'd, after the manner of the Country and of all the Orientals. We had the curiosity to measure one of their legs, which from the Toes to the Knee, was full six foot long, the Thumb of it was as big as an ordinary Arm, and the rest of the Body proportionably big' and tail. Besides these which are of the first magnitude, there are about an hundred others that are as it were ants, having the Leg from the extremity of the Foot to the Knee four foot long. In short between the first and second, we reckoned above three hundred, of which none are less than the life, and these stand upright. I mention not a great many other little towers no bigger than Puppets, which are mingled among the rest. (Tachard, op. cit.)

Passages like this tell size, shape, number, decoration, surface finish and construction method. They are often the only clue as to the appearance of the timber buildings in the ancient city. They also express the awe in which the ancient city was held.
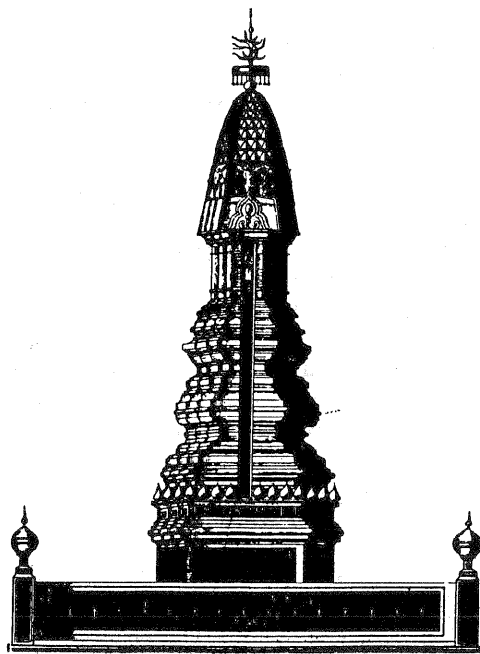

Figure 7: A Stupa, Ayutthaya. From Kaempher 1727

6. RESTITUTION OF THE PHOTOGRAMMETRY

The restitution and observation of the photogrammetry was undertaken solely for the purpose of creating a base 3D model from which the structure could be re-created. It was not the intention to create architectural drawings of the façades, nor to observe everything that was visible in the stereo-model. In fact it was more important to understand the CAD package and how individual graphical elements could be changed into surfaces than the photogrammetric process. Fortunately the Department of Geomatics' ImageStation Photogrammetric System facilitates this process.

The ImageStation (from the Intergraph Corporation) is a digital photogrammetric system, using digital image stereo-viewing on an interlaced monitor and direct observation of the photographs into a feature coded CAD data base. The colour transparencies acquired in Thailand were scanned using the Zeiss PhotoScan that forms part of the ImageStation system, although in other projects digital images from a wide range of sources have been used. Interior, relative and absolute orientations were performed on the selected stereo-pairs by observing the targetted control points as well as other parallax points. For the models restituted to date, residuals of around 0.01 - 0.02m have been obtained, around 1:2000 - 1:3000 of the maximum dimension. This is adequate for the task.

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Once the images have been epi-polar re-sampled for display in stereo, observations were then made to all of the main construction elements of the structure in a manner so that they could be used to either create a surface or derive a 'perfect' element in the CAD system (in this case, MicroStation). This consisted of observing profiles along decorative surfaces that could be made into a surface of revolution, lines along the edge of surfaces that could be connected into regular or irregular shapes and so on.
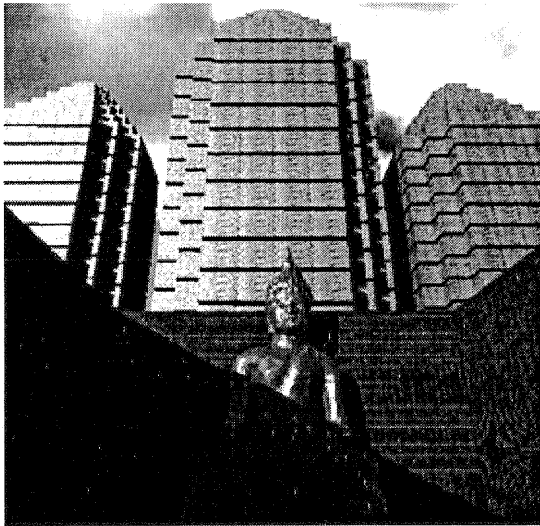

Figure 8: Buddha statue derived from a TIN model from photogrammetry.

Other, more complex shapes like say Buddha statues, are observed as a non-uniformly spaced surface model with break-lines along the main surface features. Figure 8 gives an example of one statue, and shows one of the problems of modelling real-world surfaces in a CAD system. Investigations are in progress at the University into the use of other surface modelling routines to best display irregular surfaces of cultural monuments derived from the photogrammetric record.

7. MODELLING CONSIDERATIONS

Whilst the photogrammetry provides a convenient way of quantifying the architectural forms, and the historical documentation provides some of the attributes of these forms, considerably more is needed to make the visualisation succeed. Much of the other CAD models required are created within the CAD system wholly using the imagination of the operator tempered by some geometrical constraints. For example, the main Palace buildings have been created from a combination of the archaeological plan for the dimensions of the exterior walls, photographs of the model in the Historical Research Centre, photographs of the half-scale recreation at the Ancient Thailand exhibition centre and photographs of suggested similar architectural styles. There is no building there to record, so the reconstruction is based on whatever material is at hand. A similar technique has also been used for other design elements like temple gongs and bells, oxen carts, gateways and so on.

One source of information regarding the typical architectural decoration likely to have been used at Ayutthaya are photographs in Fine Arts and Crafts publications, and photographs acquired using conventional cameras at other locations in Thailand. A selection of these photographs have been scanned, and approximately scaled as an 'ortho-image'. The MicroStation CAD software allows the display of raster images within the CAD package, allowing these 'ortho-images' to be used as a background so that intricate shapes can be traced from the pictures, and converted into complex CAD elements and hence into three dimensional shapes. This has been successfully applied to a selection of roof support brackets, windows and doors. These elements can be re-scaled to suit whatever building model they are being used to decorate.

Photogrammetry is also being used to facilitate the modelling of an elephant for incorporation into the computer model, although a real elephant was not the subject of the study. A small elephant votive has been photographed in a control frame and observed stereoscopically. A surface model has been created from the data points, and re-scaled to what would be full size within the computer. It is intended to animate this model eventually, so that the trumpet of the King's elephants can be once again heard over Ayutthaya.

8. THE VISUALISATION PROCESS

The visualisation of landscapes and cityscapes is becoming increasingly common, especially in the areas of land use planning and environmental impact studies (Bishop, 1994). Generally, as a result of the scale being considered, they have been derived from aerial photogrammetry or satellite remote sensing. In the Ayutthaya Project, it was intended to use aerial photography as a data source but eventually this was not possible, so the modelling was performed from the terrestrial photography. The creation of the models has been undertaken using Intergraph/Bentley System's Micro- Station CAD package. It is a fully featured computer aided design package, and is fully integrated into the other Intergraph

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software used for terrain modelling, photogrammetry, texture mapping and so on. However the available Intergraph animation and visualisation software is not sufficiently versatile to enable this project to reach its maximum potential, especially when it comes to the application of surface attributes and the animation of individual elements. Instead the three dimensional models have been exported into the Wavefront Advanced Visualiser suite of programs (Wavefront technologies 1995). The Wavefront software suite is a commercial animation package used to produce sequences that are currently so popular on television and in the cinema.

These operate on a Silicon Graphics Crimson workstation with a 'reality engine', enabling fast rendering times of complicated models. The computer is interfaced to a Sony Laser Disk Recording unit, configured so that individual frames of animation can be written to the laser disk under the control of the computer.

Animation sequences are scripted using the software, and the rendering instigated as a batch process on the computer. The rendered images are stored on the hard disk of the SGI, and later moved to the laser disk. The final video compilation is performed in a video edit suite, where the laser disk unit becomes just another video source.

In order for the images to be photo-realistic, the surfaces in the CAD models are given attributes such as texture, roughness, reflectivity and so on. In this project much of this operation is intuitive, there are very few cultural monuments at Ayutthaya that exhibit surface properties in the present that are in common with the period under study. There are similar monuments elsewhere supposedly built in the Ayutthaya style, and there are the artistic traditions passed down from the period. Where possible real textures are used, where this cannot be done then textures from a material library are applied instead.

9. FUTURE DEVELOPMENTS

At the moment the project has just begun, with one period of photogrammetric recording undertaken. As a result of a deadline imposed after the commencement of the project, the initial phase will be limited to the main palace region including the well known Wat Phra Si Sampet. The later phases of the project will endeavour to recreate the entire Historic City precinct.

The visualisations and animations possible for the project are not limited by human imagination, just be the available expertise and funding.

10. CONCLUSIONS

This project is one small part of the continuing work that has been occurring at Ayutthaya over the last 40 years or so, and now has become part of the larger UNESCO supported Historic City Project Master Plan. This plan intends to open up new vistas of the monuments, to replant native species, to reconstruct some of the canals and to remove some of the modern intrusions that detract from the 'Ayutthaya experience'. The project is a joint project between Thailand and Australia that not only uses appropriate digital technology to solve a problem but also ensures the transfer of this technology to where it may be most usefully applied. This project is not a continuation of cultural imperialism.

The International Committee on Monuments and Sites (ICOMOS) has published guidelines for the conservation, preservation and restoration of cultural monuments (the Vienna Charter) This document states that restoration and reconstruction work should be undertaken only according to very strict guidelines. There is always the dilemma that by recreating the monument as it was in the past destroys the very antiquity that gives the monument value. As this project hopes to show, the appropriate use of computer visualisation technology a monument can be reconstructed to its former glory so that an experience can be gained of past greatness, but not at the expense of the antiquity of the remains. In order to achieve this the technique of photogrammetry offers a rapid method of recording the current state of the monuments so as to provide a starting point for the computer's journey backwards.

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