Chapter 13

Through the visualisation lens

Temple models and simulated context in a virtual Angkor

Tom Chandler
Faculty of Information Technology, Monash University

Martin Polkinghorne
Asian Studies Program, The University of Sydney

In recent years, the shift away from the temple-centric approach of Angkorian studies has become well known (Evans et al 2007; Fletcher et al 2008; Pottier 1999). However, in the short history of the three-dimensional (3D) computer modelling of Angkor, there have been many studies of temple models (Cerezales 1997; CyArk 2006; FOKCI 2007; Visnovcova, Zhang and Gruen 2001; Kenderdine 2004; 3DreamTeam/Vizerra 2008–10; Levy 2001a; 2001b), but little consideration of the environment around the monuments. While the architectural drawing and scale modelling of Angkorian temples has a long history (see Dumarçay 1971a and b; Dumarçay and Courbin 1988; Nafilyan 1969), the modelling of these structures in the virtual world has so far followed a tradition of appraising the temples as isolated exhibition pieces and symbolic artefacts. It is argued that the narrow focus of such studies misses great opportunities in harnessing the power of the medium of 3D visualisation.

This study seeks to introduce the space *between* the temples and to produce the simulated historical, cultural and ecological landscapes that once surrounded them. The future of virtual Angkor can now move beyond digital reconstructions that are defined in only architectural terms. Knowledge about the landscape around the temples has until very recently received significantly less attention. 3D visualising of landscapes cannot reference the relative certainty of the interlocking stone assemblages but must deal with the

large, unexcavated (and therefore apparently empty) spaces where the door is open to considerable conjecture. However, while some researchers might fret about committing digital images of reconstructions to relative permanence of a printed publication, we should be mindful that virtual reconstructions remain dependably ephemeral. Physical reconstructions inevitably draw criticism[1] because they are more or less permanent, but the comparatively transient and provisional nature of a virtual reconstruction presents an underexploited contribution to scholarly investigation and debate.

Within *animated* 3D models, the permanence of a reconstruction is doubly transient, especially if the process of prototyping the model means that each time the model is rearranged, so too is the resulting image. Multiple versions are made available through the medium of 3D animation and no one view is presented as correct and peremptory. 3D animation is perfectly suited to dealing with conjecture because it patently is not real. In coloured virtual models with a roving camera, walking figures, echoing sounds and consistently alternative visions, there can be no harm in weighing historical or archaeological evidence to visually experiment with possibilities. Armed with exactly such an impermanent and malleable virtual model, it is into this breach between evidence and conjecture at Angkor that 3D animation can venture.

At Angkor, the ruins of temples have long served as focal points of scholarly interest and investigation. Even in a ruinous state, their obvious size and extent, though not their decoration is still clear today (Polkinghorne 2008:22). But what the Angkorian temples constitute today is only a 'skeleton without a body' (see Groslier 1958:108), for the wooden architecture of the humble peasant dwellings and the richly decorated pavilions of the kings have long since rotted away.

There is an established tradition of illustrated temple reconstruction in the literature (Cunin 2007; Dumarçay 1973; Dumarçay and Courbin 1988; Dumarçay and Royère 2001; Dumarçay and Smithies 2003; Parmentier 1914, 1927, 1939). The conversion of architectural drafts and plans into virtual models is also predicated on customary methodologies. The mathematical geometries used for modelling architecture are an inherent function of most all-purpose 3D programs, and many 3D applications build upon a long lineage of software evolution with roots in Computer Aided Design (CAD) programs for architecture, engineering and construction industries (Fallon 1998; Myers 1998). As architectural remains hold a natural appeal for architects, it is

[1] Among the most infamous monumental archaeological reconstructions are the various projects commanded by the late Saddam Hussein in Iraq (Vale 1999) or by Mussolini in the 1930s (Galaty and Watkinson 2004).

unsurprising that they are attracted to modelling such structures with computer software. Conversely, there is also the mathematical attraction of running the iterative architectural patterns and designs of Khmer and Indian temples through computer-generation procedures among computer scientists. Writing more than 20 years ago, Trivedi demonstrated the procedures of self-similar iteration and fractalisation in the construction of Hindu temples (Trivedi 1989) and Datta and Beynon (2005) described a computational technique for reconstructing the surface geometry of Hindu stone temple superstructures based on information derived from textual canons (*śāstras*). More recent still, Pheakdey Nguonphan's detailed study in his thesis 'Computer Modelling: Analysis and Visualization of Angkor Wat Style Temples in Cambodia' places the endeavour of modelling Angkorian temples in computational architecture, a field that combines historic architecture, computer science and applied mathematics (Nguonphan 2009). All of these approaches produce finely grained and detailed visual results and their methodologies are necessary components of visualisation studies; however, they remain intrinsically architecturally specific.

Like the computer models of Angkorian temples, scale models of Angkor are reproductions of an already created monument in miniature. The model of Angkor Wat in the Royal Palace grounds in Bangkok is a much photographed example. In 1860, following a failed attempt to relocate an existing temple (Prasat Ta Prohm) from Angkor to Thailand, the Thai King Rama IV had to settle on a much smaller scale model of Angkor Wat, crafted in the Thai capital at Wat Phra Sri Ratanasasadaram (the temple of the Emerald Buddha) (Kasetsiri 2003). Curious stylistic embellishments in the modelling of this replica of Angkor Wat (Fig. 13.1A) lend it a uniquely Thai interpretation and hint at deeper conceptions of what the heritage of Angkor means to Thailand's historical identity (Ünaldi 2008). Similarly, in the late 19th and early 20th centuries three-dimensional replicas of Angkor's art and architecture were used to promote the wealth and curiosities of France's colonial assets. Casts of artworks made by Doudart de Lagree were shown at the Exposition Universelle in Paris in 1878. In 1889, a replica of Angkor Wat's central tower was erected in the Palace des Invalides and an almost life-size expanded model of the temple was shown in Marseilles in 1922, and again in Paris 1931 for the Colonial Expositions (Fig. 13.2B) (Dagens 1995:104; Edwards 2007). Recently, numerous cement models have emerged in the gardens of Khmer families of Siem Reap (Fig. 13.2A).[2]

---

[2] Scale models of temples are becoming increasingly common in the Angkor area today. Examples can be found at the Bakong temple and the Banteay Srei Rachana workshop on the banks of the Siem Reap River. Miniature replications abound in the markets in the form of key rings, paperweights and clocks.

Figures 13.1 The model of Angkor Wat in the grounds of the Royal Palace at Bangkok.

Figures 13.2A and 13.2B On the left, a scale model of Angkor Wat near the Bakong temple site, Siem Reap. On the right, a photograph of the reconstruction of the central towers of Angkor Wat at the 1931 Paris Colonial Exposition.

The computer models of Angkorian temples are similar to the real-world models in that they mimic the sharp orthogonal views of the architectural draftsman into the 3D computer drawing space. The models are marooned in a digital space and entirely cut off from their cultural context. If the analogy of the temples as the 'religious skeleton' of the city can be extended, these visions equate to the bones of the skeleton having been removed and each displayed in separate glass cases.

While recent restoration studies suggest that parts of the temples were brightly coloured and variously decorated (von Plehwe-Leisen and Leisen 2005, 2008), most digital reconstructions of temples remain decidedly coy about such uncertainties. Levy's observations on rebuilding a virtual model of the temple of Phimai are relevant here:

> Creating an accurate surface treatment is both an art and science. If the goal is to show the monuments as they existed centuries ago…current photos of surface detail must be renewed or reversed in age. Samples of cut quarry stone can help in establishing the colour and luster of materials as they once appeared in the past (Levy 2001b:7).

Interestingly, both the Phimai (Levy 2001a and b) and Heidelberg (Interdisciplinary Center for Scientific Computing 2007) studies situate their reconstructions against a background of finely manicured lawns.[3] Whether this is intended to be the historical context is not clear, but both studies seem to suggest that they use 3D space solely as a kind of digital anastylosis,[4] where the computer assists in visualising the original form of the ruined architecture by reassembling its constituent parts. Aside from the stones being cleanly cut, redressed and reset in the appropriate place, such reconstructions venture nothing more about how the temples might have actually appeared when operational, or what their environs might have looked like.

While surviving stucco features on numerous *prasat* are well known (Fig. 13.3), researchers have also drawn attention to evidence of painted decoration and plastering (von Plehwe-Leisen and Leisen 2005; Uchida et al 2005; Falser 2007). Von Plehwe-Leisen and Leisen (2008:367) argue that the stone and brick surfaces of the temples were covered by paint layers with or without washes, plaster, and stucco. Polychrome decorations were applied directly onto the surface of the stone or over a thin lime wash, and microscopic analyses have yielded pigments of gold, cinnabar, red and white lead, iron red and ochre (von Plehwe-Leisen and Leisen 2008:368).

---

[3] A reconstruction of one of the libraries of Angkor Wat on the University of Heidelberg website features snow-capped mountains in the background.

[4] Anastylosis is a method of architectural conservation pioneered at Angkor in the 1930s by EFEO Conservator Henri Marchal on the temple of Banteay Srei. The method involves the de-assembly of the monument and its re-erection using its own materials.

Figure 13.3 Stucco rendering laid over brickwork amidst a sandstone representation of a *dvarapāla* at Preah Kô.

Zhou Daguan refers to 'gold towers' (gilded towers) at the Bayon and Phimeanakas and accounts of Portuguese and Spanish visitors in the 16th century suggest that the towers of Angkor were covered in gild and crowned with globes, banners and bronze tridents (Groslier 2006:71). Such decorations, however minor, were no doubt strategically placed and would have lent considerable visual impact to the temple as a whole. Given the opportunities for suggesting possible reconstructions within the 3D medium, it is surprising that so many Angkorian temple reconstructions have stubbornly stuck to monochrome visions. Indeed, colour is one archaeological reality of Angkor that is seldom expressed in visual descriptions, though a *National Geographic* article featuring paintings by Maurice Fievet (Moore 1960) is a well known exception. In this widely published vision of Angkor as a vividly coloured living city, the illustrations paint lively scenes full of rich red, green and blue fabrics in technicolour, and a great deal of gold ornamentation. Intriguingly, these colours adorn everything but the temples which remained relegated to a uniform cement grey.

Though Zhou Daguan mentions gold towers and faces at Angkor, and there are obvious remains of plaster stucco, the physical evidence for the colouration of the temples is scant. Very little paint work or stucco has survived the centuries of the tropical climate. There is evidence of polychrome decoration and plastering *inside* some of the ruins, but to date no clear evidence of colour has emerged on the many thousands, if not millions, of tumbled stones in the Angkor area. In the words of Carl Sagan, absence of evidence is not necessarily evidence of absence. As a broader analogy,

we might consider the field of palaeontology, where renderings of dinosaurs have gradually evolved over the years from grey-green Victorian 'iguanodons' that haunt the grounds of Crystal Palace on the outskirts of London. Today popular science literature depicts dinosaurs as brightly coloured bird-like creatures, despite the lack of hard evidence.

Some experimentation with temple colours has taken place at the fringes of 3D representation. The Siem Reap-based artist Bruno Truffert, on his website Angkor Planet, has used the 3D medium to trial one extreme of possibilities in temple decoration by bringing to bear a wider palette of colours. Citing examples of the highly coloured and decorated original forms of Greek and Roman temples, the colours of Indian temples and the evidence of painted architectural forms in present day Cambodia, Truffert's visions of Angkor suggest fantastic temples rendered in dazzling colour combinations passed by bicycles, cars and aeroplanes (Plate 13.1).

The visualisation of Khmer temples would benefit from a reappraisal of a 'grey' Angkor to one that includes even partially painted attributes. The recent painstaking research into one possible colouration for the central enclosure of Angkor Wat, published as a fold-out supplement in the July 2009 issue of *National Geographic,* is an inventive elaboration of this issue.[5]

Computer-generated images (CGI) in archaeological documentaries have also experimented with colour—for example, Philip Day's 2002 documentary *Lost Worlds: City of the God Kings* (Plate 13.2). Using a mix of live-action footage and CGI sequences, the digital animations set a precedent in composing the first computer vision of a living, medieval Angkor. Colour played a valuable part in image production; the *prasats* were decorated in fringes of red, green and blue, and the tentative reconstruction of the Royal Palace was washed with an imperial red. Wide-ranging renders of Angkor Thom (Yaśodharapura) were cloaked in smoky sepia tones, suggesting the composition as somehow archival. In addition to the decorated stone temples, the images in Day's *City of the God Kings* also depict cultivated vegetation and wooden buildings.

The environment around the temples provides the most exciting opportunity to speculate about the 'look' of a living medieval site. Angkor Wat forms a rectangle of about 1,500 by 1,300 metres, and covers an area—including its 190 metre wide moats—of nearly 200 hectares. Some telling descriptions of Spanish and Portuguese travellers in the 16th century

---

[5] The magazine illustrations were by Bruce Morser. The magazine researchers consulted widely with members of the Greater Angkor Project and also referenced selected visualisations created by Tom Chandler and Michael Lim at Monash University (see Stone 2009).

describe it as an operational temple with gilded statues. To the 3D visualiser and animator, even more valuable are the descriptions of the temple's decorations, which illustrate features no longer in evidence today.

The Portuguese traveller and trader Diego do Couto described the five towers of Angkor Wat as gilded and topped with globes and banners; further accounts by Antonio da Magdalena and Christoval de Jaque also mentioned details of bronze- or copper-gilded balls (Groslier 2006). Groslier points out that the Khmer inscriptions often refer to tridents and banners which decorate the temples. Gifts of decorative banners are mentioned in 17th-century texts. Furthermore it was highly likely that the towers at Angkor Wat were gilded, including metal finials (Groslier 2006:17). For the animator, the addition of windblown banners and pennants to an otherwise motionless structure holds obvious appeal. It may not be a representation of Angkor Wat, but a graffito discovered and outlined at the Bayon by Japanese archaeologists (Nakagawa, 2003) suggests wispy, tapered textiles fluttering from a spire atop a *prasat* as if sketched from a European fairytale (Fig. 13.5A). The July 2009 fold-out illustration of Angkor Wat in the *National Geographic* magazine resulted from considered consultation with Angkor researchers[6] and also conveys a series of decorated towers and banners.

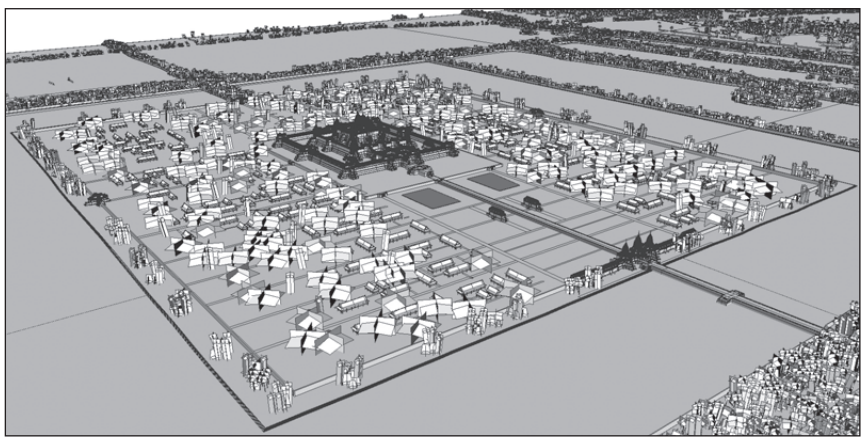
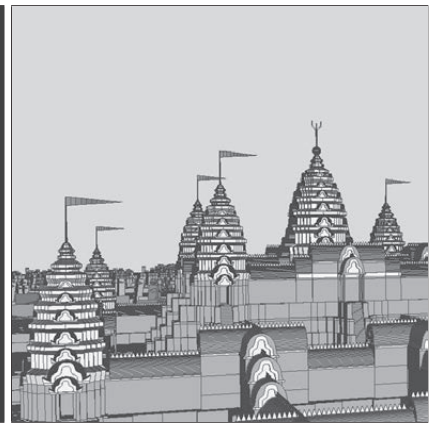


Figure 13.4 A view inside the workings of the model of Angkor Wat. Although the areas approaching the horizon are empty, they have been made invisible to save processing power.
(3D model created by Tom Chandler and Michael Lim)

[6] Including the present authors and Christophe Pottier. The visualisations are used here as reference pieces.



Figures 13.5A and 13.5B On the left, the chalked outline of a graffito in the Bayon temple, clearly indicating a windblown pennant attached to the top of a spire (Nakagawa 2003). On the right, an image showing the preparation of virtual physics for the banners in the 3D model. Here, the fabric looks as if it is being buffeted in gale-force winds, but this is because the subtleties of the flowing cloth are only realised once the model is rendered in an animation.

When we move beyond the intricacies in detailing the edifice of Angkor Wat to the enclosure around it, we encounter problematic issues in the visualisation of Angkor's medieval urban form. While the walls of some temple complexes, such as Preah Khan and Angkor Wat, enclosed immense spaces, the temples themselves occupy a comparatively small fraction of this area. Groslier attempted to describe the operational city:

> In the middle of the city the temple formed a separate town of its own. Between the sanctuary and its surrounding wall rose a labyrinth of buildings which housed a whole population of priests and assistants (Groslier and Arthaud 1966:162).

If the temptation to see the walled temples of Angkor enclosing self-contained urban centres like the walled towns in China or Europe is hinted at in the excerpt above, very few illustrations or images have attempted to imagine it. The inscriptions offer little information about how many people lived within the major temple enclosures. For example, the Ta Prohm inscription refers to 12,640 'staff', but only states that the total includes those residing in the temples (see Cœdès 1906:11–52 K273).

Angkor Wat has been continuously operational since its construction and, when colonial visitors arrived in the late 19th century, a community

of monks was living in front of the central enclosure. As part of France's colonial 'restoration', the wooden buildings of the *sangha* were considered an eyesore and were removed in 1909 to satisfy the tourist desire for the 'picturesque' (Edwards 2005:17–18, 2007:125–143; Winter 2007:32; see also Glaize 2009:57) (Fig. 13.6). Interestingly, the set for the movie *Tomb Raider* in 2000 seems to have had wooden houses and structures temporarily reinstalled in a mock village in the same position.[7] Just as there are several Theravada complexes within the outer walls of Angkor Wat today, it is likely that the temple walls also enclosed an array of wooden buildings.

Figure 13.6 A photograph of thatch dwellings near the north side of the galleries and porticos of Angkor Wat in the early 1900s
(Dieulefils 2001:39)

It is uncertain that Angkor Wat was a temple and a walled city. Jacques (1999:49–50), however, suggests that the roads leading from both sides of the causeway are a grid of streets of 'the original city'. Similar layouts revealed within Angkor Thom (Gaucher 2007; 2002a) and at Banteay Sras in western Greater Angkor by Sonneman and Fletcher, suggest more than empty space. While future archaeological investigations may reveal what was within these walls,[8] visualisation experiments can explore the possibilities. Dozens, if not hundreds of illustrations and 3D models of

[7] See Figure 2 in Winter (2002).

[8] Results are anticipated from the mid-2010 Greater Angkor Project excavations within the enclosure walls of Angkor Wat.

Angkor Wat (both scholarly and popular) can be gleaned from a search on the internet. The majority of these graphic depictions present renditions of the same stone architecture, walls, ponds, causeways and moats that remain in place to this day. Although there is no obvious trace of a city or a palace within the boundaries of the great temple, Jacques writes that there is little doubt the outer walls enclosed a capital, including a royal palace placed north of the temple (Jacques 2005:152). Jacques argues that Angkor Wat may have been originally accessed not primarily through the front, western pavilion, as it is today, but along wooden bridges which connected with the cart ways crossing the north and south entrance pavilions. (Jacques 2005:156). These connecting bridges are apparent in the Japanese plan of Angkor Wat drawn in the 1600s, though Péri (1923:126) argues that the three additional bridges can be accounted for by the desire for symmetry in the unknown draftsman who redrew Shimano's rough plans from notes and interpretation.[9]

Little information about the possible contents of the enclosures has been gleaned from archaeological surveys or from historical accounts; however, it is likely that Angkor Wat contained an array of structures and habitation.[10] These matters may be resolved through further invasive archaeological research, but, in the meantime, 3D visualisations offer the utility to test possibilities with visual experiments. For example, did the empty spaces contain large wooden storehouses and official residences or only a scattering of more modest abodes? Could perhaps a proportion of the land inside the precinct have even been cultivated? As a foundation for the 3D visualisations, architectural plans of Angkor Wat are abundant.[11] One possibility considered by our visualisation was to populate the open areas of the Angkor Wat enclosures with a set of wooden buildings patterned along the grid roads within the outer enclosure. Clusters of trees were scattered in a similar manner, with large, solitary and presumably considerably aged types being most visually apparent. The placement and swapping of larger wooden structures and tree models generated new combinations each time the computer was directed to visualise the scene. In attempting visualisations of the entire enclosure of Angkor Wat in the

---

[9] It would be interesting to test the inclusion of these wooden bridges in the virtual model, but this will have to wait for a later study.

[10] The remains of *prasat* bases have been revealed in ground-penetrating radar analysis by Till Sonneman and excavation by the Greater Angkor Project in 2010.

[11] There is no shortage of general top-down plans of Angkor Wat to model against, but for illustrated profiles of the temple as a reconstructed edifice, undoubtedly the best source was Nafilyan (1969).

medieval period, we can venture the possibility that it was something other than a lonely monument in a featureless green lawn and can also distinguish it from walled medieval European or Chinese cities with densely crowded wooden buildings.

In addition to a visual speculation of the contents of Angkor Wat's enclosures, 3D models can position the great monument in the cultural landscape which lies beyond its moat.[12] Our visualisation depicts dense settlements along the outside banks of the moat, the rising bulk of the Bakheng hill (capped with a model of the Bakheng temple) and the road leading to the south gate of Angkor Thom.

The image of Angkor Wat (Plate. 13.3) captured from one of the animations supplied to *National Geographic* (Chandler 2009) followed a classic archaeological documentary format of a flying semi-circular arc, approaching from the south and swinging around to the northeast. The space between the temple and the moat is patterned with modular sets of varied representation—large trees and sizeable wooden structures—which regenerate in slightly different places each time the animation is rendered. Colour and lighting effects have been applied in successive layers and we can see the water of the moat, the dark green of the trees and the gilded towers shining through a tropical haze. Sounds also accompany this animation.

In addition to the totality of the temple complexes, the trees and vegetation of medieval Angkor have similarly not been adequately articulated in 3D visualisations. Though there is substantial evidence in palynological studies (Penny et al. 2006, 2007), epigraphy (Jacob 1978), historical accounts (Loti 1989; Mouhot 1868), historical illustrations (Delaporte and Garnier 1998) and the contemporary landscape, the inclusion of trees in virtual visions of Angkor is usually used as a device to indicate decay and abandonment.[13]

Originally bound to a 19th-century concept of revitalising a culture in decline (Edwards 2007:125–43), the earliest interventions of the École française d'Extrême-Orient (EFEO) at the turn of the 20th century considered clearing of the Angkorian monuments as the best approach to recognise the architectural and artistic legacy of Angkorian civilisation.

---

[12] Cartographical information is provided from the Greater Angkor Project map (see Pottier 1999; Evans 2007).

[13] The image of the silk cotton tree strangling the galleries of Ta Prohm has become not only a photographic cliché but a literary one as well, prompting 'more writers to descriptive excess than any other feature of Angkor' (Jacques and Freeman 1999:136).

The necessity of French researchers to 'clear' the structures, which, on first inspection must have appeared impossibly chaotic in their foliage-covered state has transposed into virtual reconstructions where the trees are removed and replaced by the manicured lawns. Particular species of trees maintain religious and utilitarian associations with Buddhist pagodas in Cambodia, Thailand and Laos (Fig. 13.7). Dumarçay and Royère (2001:52) suggest that *hopea odorata*, commonly known as Koki trees, were planted within temple environs, corresponding to the necessity to renew beam work. Sugar-palm leaves used for temple manuscripts and *ficus religiosa* trees are considered sacred because of their associations with the narrative tradition of Siddhartha Gautama. Pollen samples dating to the medieval period at the Bakong and Sras Srang sites indicate temple grounds were deliberately planted with stands and groves of trees.[14]

In a study on gardens and Hindu–Buddhist architecture in Java, Satari (2008) notes numerous references to the establishment of temple gardens in temple reliefs and epigraphy. These sources distinguish between plants cultivated near a hermitage and around the royal palace ground. The density of vegetation in central Angkor during the medieval period is not known, but by considering the historical and palynological evidence we can begin to hypothesise a living context around the stone structures. Figures 13.8A and 13.8B show Angkor Wat from the north; while the temple itself has faded from view, the landscape in the foreground is in sharp relief. Each image patterns the model clusters with different densities, allowing us to experiment with the intersection of the mapped landscape and the features that are patterned over it.

There are many examples of digital visualisations that consider monumental 'state' architecture, but none that reflect on the local shrines and their context where the majority of the medieval Angkorian population lived and worshipped. In the 1950s Groslier (1958, 1959a, 1979) began to hypothesise that Angkor was a 'hydraulic city', where a large-scale system of canals, embankments and village ponds was integral to the operation of the 'city'. Embraced by Pottier (1999) and Evans (2002, 2007; Evans et al 2007), remote-sensing techniques and substantial ground survey confirmed key aspects of Groslier's thesis and revealed a vast urban settlement characterised by village shrines constructed in both durable and 'temporary' materials stretching across nearly 2,000 square kilometres.

---

[14] Dan Penny (personal communication, July 2010)

Figure 13.7 A 19th-century rendition of the environs of the Royal Pagoda in Bassac in Southern Laos showing large trees shadowing the foreground of the image
(Drawing by E Tournois, based on a watercolour by Louis Delaporte)

Figures 13.8A and 13.8B Two contrasting views from the north of Angkor Wat in the virtual model. The image on the right has twice the number of clusters of trees and dwellings as the one on the left. These two images show the result of random repatterning of model clusters both inside the compound of Angkor Wat and in the landscapes surrounding the moat.
(Images created by Tom Chandler and Michael Lim)

As a relatively contained village settlement on the Angkor plain, the site of He Phka just to the north of the Tonle Sap lake was considered as a potential location for a 3D visualisation of a village shrine *in situ*. It appears distinctly on the Pottier's (1999) archaeological survey of the south of Angkor as a U-shaped moated temple site surrounded by a conglomeration of mounded areas and ponds (Fig. 13.9). Today, the site is scattered with brick fragments and laterite blocks, but, based on a survey conducted by Pottier, we can envisage that the central mound once housed three towers, open to the east, with one *gopura* and one brick enclosure wall passing 12 metres north of the north tower.[15]

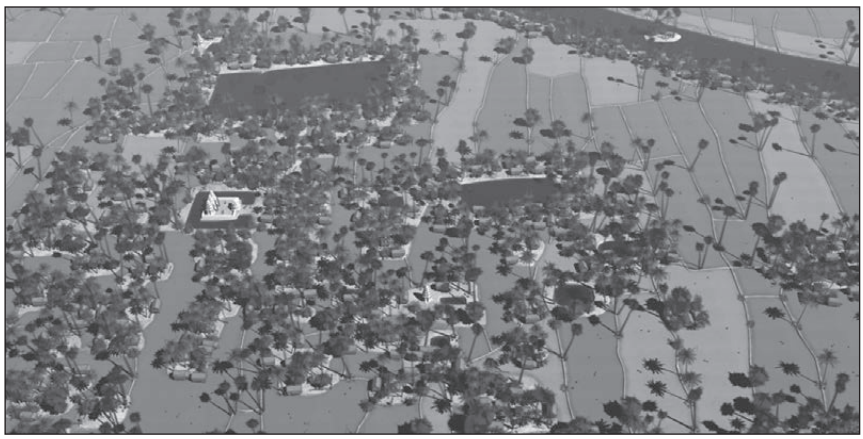


Figure 13.9 A visualisation of the village of He Phka as drawn from Pottier's archaeological mapping (1999). Colours are matched with samples from contemporary photography in the area.
(Images created by Tom Chandler and Michael Lim)

When considering an animation of the Greater Angkorian landscape, it was necessary to include numerous local shrine sites. Corresponding to the ability to represent variation in settlement clusters of trees and houses, we can provide nuanced interpretations of the 'styles' of village shrine models. Seen from afar in the virtual model, the 3D village shrines partially obscured by trees appear to be one of the three architectural models, but they are agglomerations of additional stylistic layers and colour schemes overlaid in a modular fashion.

[15] Christophe Pottier (personal communication, June, 2010).

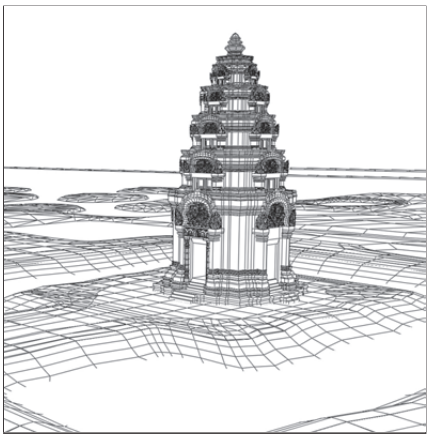
Greater Angkor developed as a dispersed low-density city over a period of roughly 600 years (see Evans et al. 2007) during which architectural and artistic styles changed considerably. The artistic genius of the medieval Khmer was an ability to change, modify and invent temple forms in a multitude of combinations. Inconsistency in temple design and form is related to last-minute decisions, reversals, recombinations, medieval restorations, de-consecrations, demolitions and the successful execution of 'inconsistent' plans. The temples we see today can be regarded as cumulative monuments that underwent numerous and different transformations. 3D visualisation of the village *prasat* has the ability to represent the actual diversity and variation that pervades the material culture. To represent the inherent variation in the architectural landscape, a series of three *prasat* were produced broadly corresponding to the artistic 'styles' of the seventh, tenth and 12th centuries.[16] Additional variation is integrated within each designated 'stylistic' period and the *prasat* are divided into another three subsets that distinguish building materials. For example, a shrine of the tenth century might be rendered as either brick, sandstone, laterite, or a combination of these materials. Supplementary variations of colouring, plastering and decoration compose these models differently again resulting in nine nominal combinations of *prasat*.

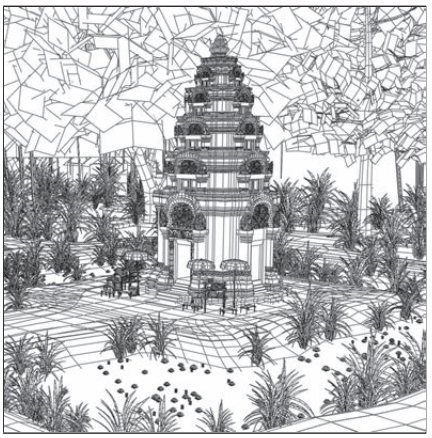
With an interchangeable array of 3D settlement, landscape and *prasat* models, we can create a non-specific local shrine and village scene. The ability to vary the modular components of the scene allows us to apply the model to nearly any location in medieval Angkor. While the moat, mound and the shrine model serve to define the layout of the site (Fig. 13.10A), it is crowded with many other modelled components (Fig. 13.10B). Pandanus plants fringe the banks of the moat containing scattered lotuses. The shrine is decorated with brightly coloured lintels and its entrance flanked by wooden stands with baskets and parasols. In the background are stands of large trees that shade the entire scene. When we apply light and colours (Fig. 13.11), the vivid red flowers of the *bombax ceiba* tree accent the dusty green canopy and we can see dappled sunlight upon the trodden red soil where a number of figures stand. As well as the animation of the walking figures and waving pennants, the visualisation is layered with atmospheric sounds that fade in and out of earshot to suggest an added spatial dimension to the scene portrayed.[17]

---

[16] These categories do not correspond to the artistic 'styles' designated by French art historians of the early 20th century to describe the broad characteristics of Khmer art over more than 700 years (see Coral-Rémusat 1940; Stern 1927), but are generalised architectural composite models representing periods of approximately one year.

[17] See Chandler (2009).





Figures 13.10A and 13.10B Two images showing the geometrical underlay behind the 3D render of the shrine in Figure 13.11. On the left, the moat, causeway and architectural model of the shrine. On the right, a wide range of vegetation models crowd the background and foreground of the image, together with wooden religious paraphernalia placed around the shrine's main entrance and a draped pennant on long bamboo poles.

Figure 13.11 A 3D image of a village shrine. A pair of Theravada monks walk towards the viewer, while other figures can be seen sitting in the shade of the nearby wooden shelters, conversing on the causeway and in the foreground. The air here was 'thickened' with a tinge of yellow to mimic humid air permeated with dust or smoke.

(Images created by Tom Chandler and Brent McKee)

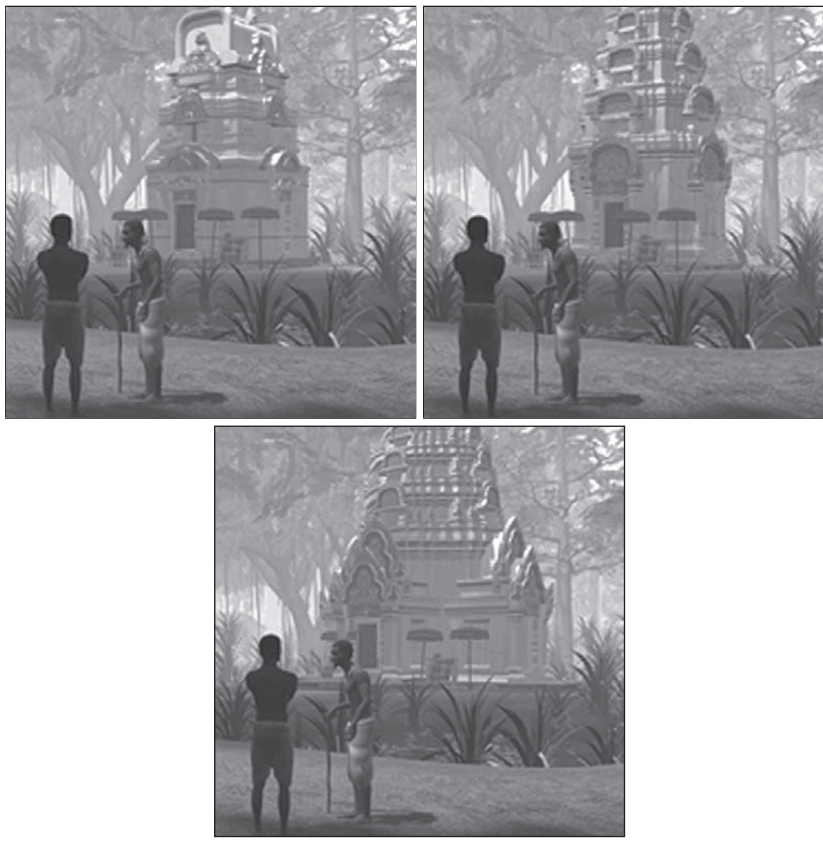


Figure 13.12 The camera is at ground level emphasising talking human figures. Each image appears superficially similar, but in the background, the shrine models have been interchanged between the three distinct architectural 'styles'.
(Images created by Tom Chandler and Brent McKee)

The scene can be augmented by interchanging the modular shrine 'types' and vegetation models. For example, swapping the hulking, shading mass of a *ficus religiosa* for the slender stands of areca and sugar palms changes the effect of light. The employment of generic shrine 'styles' is distinguished from the meticulous techniques of computational procedural architectural grammars (see Müller et al. 2005, 2006); however, these visualisations place a new and augmented importance on the cultural and environmental landscapes.

When Angkorian architectural models are considered in their historical landscapes, archaeological visualisations can be refocused from the geometrical phenomena of architectural structures to the pluralities and uncertainties of 'living sites' populated with wooden architectural models, colours, vegetation

and animated forms. Creating these models inevitably involves extrapolation from incomplete and inconsistent epigraphic, archaeological and art history sources. However, 3D visualisation offers scholars the unique opportunity to hypothesise with plural reconstructive possibilities. At Angkor, where the landscape between the temples was previously rendered merely as 'jungle' or 'white voids' on the printed page, we can begin to address archaeological uncertainty with shifting patterns of wooden buildings, trees, settlements and village shrines. And, finally, in this space of interchangeable elements, moving figures and simulated sound, we can begin to explore the wider potentials of what a historical 3D computer model might offer to scholarship in the digital age.

Acknowledgements

The authors are indebted to the 3D modelling and animation expertise of several research assistants at Monash University who ensured the quality of the digital images reproduced in this chapter: Michael Lim, Brent McKee, Chandara Ung, Janet Saw and Carol Merlo. Unless otherwise indicated, photographs were taken by the authors. Martin Polkinghorne wishes to acknowledge the support of the Greater Angkor Project, the Authority for the Protection and Management of Angkor and the Region of Siem Reap, l'École française d'Extrême-Orient and Heritage Watch. Research was conducted with funding from an Australian Postgraduate Award, the Carlyle Greenwell Bequest and an Endeavour post-doctoral fellowship.