3D VisA
3D Visualisation in the Arts Network

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Edited by Anna Bentkowska–Kafel

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Editorial

Will computer modelling get better? This question was raised by Michael Greenhalgh in the September 2006 issue of the 3DVisA Bulletin. The concern seems common to all those who create and use 3D visualisations, as well as those who think it is far too early to consider environments created within a computer as credible research tools. I am delighted that the question has provoked much debate, and am pleased to be able to include in this issue Angela Geary's response to Greenhalgh's scepticism as expressed in his review of the computer model of the temple site at Phimai. Geary's argument, founded in years of research experience in this field and a background in fine arts and conservation, carries considerable weight. She is fully aware of the technical limitations of software and other problems, yet with her trust in creativity – not surprising for an artist – she sounds optimistic: 'There is no longer a specific barrier, other than our imaginations, to developing a new generation of visualisation tools that can fully represent the richness of the visual, geometric and time-based data that can be acquired from artefacts.'

Robert Laycock and Stephen Laycock contribute to the same discussion by presenting new haptic technologies for generating high-quality computer-generated environments. They draw on a number of projects they have been involved with in the area of architectural and urban studies and demonstrate new possibilities for creating pseudo-tactile, immersive virtual spaces.

There is no question that the ever greater photo-realistic capacity of computer graphics and life-like behaviour in the latest generation of virtual environments makes them increasingly more attractive. An historical overview of the developments in this area over the last forty years was presented at the Barbican *Game*

On exhibition, which has just closed at the Science Museum in London, having toured Europe and the US since 2002. The technological leap from the early games of the 1970s to the latest releases is remarkable. The Nintendo Wii and Sony PlayStation 3 consoles, demonstrated at the last, London leg of the exhibition ahead of their UK release, alongside Sony's new 'communication game', *Eyetoy*, are proving the extent to which technology is becoming an invisible part of the computing experience. This is now becoming an intuitive and all-encompassing interaction. Non-profit academic application creators can only look with optimism at the technological race in this multi-billion dollar global industry.

Arts and humanities computing continues to benefit from developments in other areas. Some of the doubts concerning the visual and operational qualities of 3D computer environments may eventually be dispelled thanks to models developed elsewhere. However, heritage visualisations continue to raise subject-specific problems. The credibility of an historical visualisation cannot be guaranteed by photo-realism alone. Paradoxically, photo-realism may on some occasions contribute to a fake reconstruction. While encouraging creativity and the application of novel techniques, 3D visualisation of heritage demands rigorous methods to ensure that the persuasiveness of visual arguments does not exceed what the evidence justifies. This issue is being addressed by *The London Charter*, the proposed standard for heritage visualisations, now open for consultation (*www.londoncharter.org*). The digital reconstruction of archaic artefacts excavated in the Etruscan Caere, today's Cerveteri, illustrates this concern. A terracotta slab with a painted figure, of which only a fragment has survived, provided the basis for a complex digital reconstruction of a temple which might have been decorated with this slab, and its surroundings. The aim of the project, discussed here by Luciana Bordoni and Sandro Rubino, is to place this computer modelling in the context of a wider information system, not excluding the poetic memory of the past.

I hope you will enjoy reading the articles. Full text and more illustrations, including animations are available online. As advertised, these pages are intended as a forum for a community-wide debate on topical and current issues in 3D visualisation. The scope for experimentation and innovation is huge. 3DVisA is offering an award, aimed at students who are prepared to respond to the challenges detailed above. Please see the 3DVisA website for more information. Your comments and contributions to future issues are welcome. ■

Featured 3D Method

HAPTICALLY AWARE MOVIES. Touching High-Quality Computer-Generated Environments

by Robert Laycock and Stephen Laycock

Large volumes of high-quality digitally archived cultural artefacts exist today with the content increasing every year through advancements in data acquisition. Two-dimensional maps, three-dimensional vases and digitally preserved caves are among the items recorded within a computer. It is vital to organise such a vast and culturally diverse collection to ensure that it may be utilised to its full potential. Of significant importance in collecting such a dataset is the ability to enable the public to appreciate their heritage. An ideal candidate for performing this task is the virtual environment, since it enables the integration of both the three-dimensional and two-dimensional information into a readily accessible format. By combining the data into a single three-dimensional environment the user is able to experience an interpretation of a lost world through sight and sound. The desire to create an environment which completely immerses the user has motivated the novel approach discussed in this article, which augments the visual and audio experience with the sense of touch owing to the Phantom Desktop, a haptic feedback device capable of exerting forces on the user.

Since the early 1960s computer scientists have attempted to recreate real environments by creating synthetic worlds, which engage the user to the extent that they believe their surroundings are real. Achieving such an immersive experience involves fooling the five human sensory systems. Over the past decades both computer hardware and software have been developed for interfacing with the visual, auditory, gustatory, olfactory and somatosensory systems; the most rapid and compelling interface being for the visual system. Technology in Computer Graphics has increased significantly enabling high-fidelity images to be created indistinguishable from their real counterparts. This technology has facilitated the creation of complex virtual environments, driven by the digital artist's imagination.

Reconstructing the physical world inside the computer is a particularly challenging and frequently time–consuming task. The recreation of urban scenes has received much interest owing to its many applications ranging from cultural heritage through virtual tourism to urban planning. The former is stimulating multidisciplinary discussions between computer scientists, digital artists and historians. For instance, imagine working on an archaeological site discovering a variety of artefacts, each being a piece in the puzzle of the life that once existed. In the physical world their story is told from within glass cabinets, perhaps annotated with text or a few images. The virtual environment provides one medium in which all these pieces may be brought together and visualised within the intended spatial and temporal context. By integrating audio and dynamic content the scene comes alive, enabling the virtual visitor to obtain a better understanding of the artefacts and their respective uses.

Motivated by the desire to offer an ever more immersive experience, devices have been constructed to engage the olfactory and gustatory systems. However, these have had limited success, with devices confined to research labs simulating only a handful of tastes and smells. More popular among both academic and industrial sectors is the ability to touch three-dimensional objects within a virtual environment, as if the objects were right in front of the user. A haptic feedback device offers this capability enabling a user to obtain a better appreciation of an object's three-dimensional form, without causing adverse effects to the object's conservation.

When considering developing an immersive virtual environment to depict cultural heritage there are a number of concerns. For instance how are these high-fidelity photo-realistic environments constructed and, once constructed, what is required to enable a user to explore the virtual world utilising their senses of sight, sound and touch. The full online article considers these questions and proposes a novel concept to tackle them entitled *Haptically Aware Movies*.

Our approach is inspired by S.E. Chen's QuickTime VR paper (1995) which describes a number of techniques that enable the visualisation of offline rendered movies in real time. In order to permit interaction with the images two stages are required. First, the appropriate high quality images must be determined and second, a framework must be developed to handle the rendering in real time whilst permitting user interaction. Our environments are generated in 3D StudioMax which is capable of rendering the necessary high-quality images.

To obtain a sequence of images a camera must be positioned to move along a path through the environment in discrete steps. However, in this approach six images are required at each step instead of just one, as used in standard movie generation. Therefore six cameras must be collocated and configured to move along a path in 3DS Max. Each of the six cameras has a field of view equal to 90 degrees and is orientated to point along the six axes of a three dimensional coordinate system. Fig. 1 illustrates the path and six cameras used to capture images of a computer generated street. To ensure this configuration can be set up efficiently MaxScript is written.

Fig. 1. A computer-generated environment containing a camera path and six cameras collocated. © Urban Modelling Group

Acquiring the six sets of images for discrete steps along the camera path is only part of the solution, since these images must be displayed appropriately. The real-time component can be programmed using OpenGL, a graphics library for displaying interactive graphics. Each set of six images captured in 3DS Max can then be displayed on the faces of a cube rendered in OpenGL. Fig. 2 illustrates the net of a cube and the cube map itself, showing how the images are applied to the cube faces. A seamless visualisation of the computer generated environment can be seen by viewing the cube from its centre point looking out. This figure indicates an example cube map in OpenGL where the viewer is positioned at the centre.

Each set of six images are then changed simultaneously to enable the user to perceive a continuous motion. The sequence of images used for the front face of the cube can be thought to be identical to a standard movie, as if one camera had been used. However, the advantage of rendering six images instead of one is that the user is able to rotate their view to any desired orientation whilst the movie is playing. This can be thought to be similar to moving on a train, where the path is fixed, but you may look around as you travel.

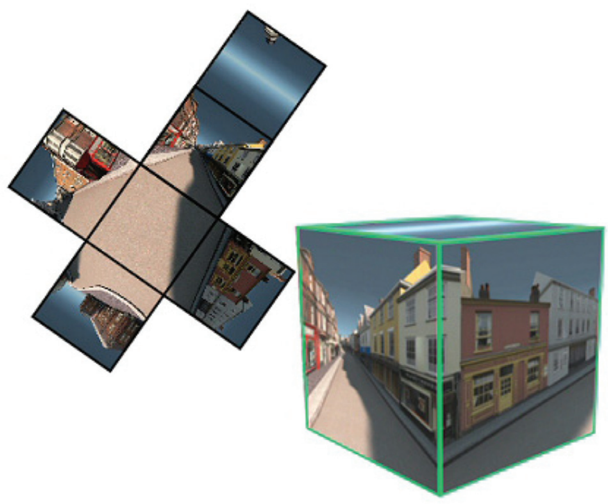

Fig. 2. A net of a cube with a separate image displayed on each square and the resulting cube. © Urban Modelling Group

The approach outlined is ideally suited to the navigation of computer generated environments involving semi-prescribed routes. It is therefore appropriate for virtual guided tours where a user traverses a route with the ability to alter their direction at key points. Furthermore, by incorporating a haptic feedback device the user can feel all around a three-dimensional object. ■

More at www.viznet.ac.uk/3dvisa

3DVisA Discussion Forum

IS REAL-TIME PHOTOREALISTIC 3D VIEWING ON THE HORIZON?
Angela Geary responds to Michael Greenhalgh

Michael Greenhalgh's question from the previous issue, 'Will computer modelling get better?' struck a chord with me. Like Michael, I'm exasperated with the quality of real-time 3D representation that has been available for the visualisation of cultural heritage datasets. I, too have struggled in my attempts to represent authentic surface texture, colour and materials of complex surfaces, on a par with the high-resolution 3D geometry that can be captured from artefacts. Obtaining such high-resolution data has become readily achievable using standard, close-range 3D laser scanning techniques. To realise a photo-realistic result in a virtual representation, however, one has had to rely on rendered output to still images or digital movie formats such as QuickTime® or Audio Video Interleave (AVI). QuickTimeVR® offers a noteworthy repertoire that includes the potential for basic interactivity such as object rotation and zooming. Unfortunately, this image-based format falls well short of an ideal scenario in which the live exploration of actual 3D geometry would be possible in conjunction with a high-quality rendered appearance.

Virtual Reality Mark-up Language (VRML) purported to offer this functionality, yet it is very limited with respect to surface shading. VRML supports only basic shading models such as 'Phong', it has limited potential for texture mapping and it offers no reliable integrated method for shadow projection. In practical applications, all of these characteristics are essential to realistic representation in an interactive environment. VRML's successor, X3D, has greater depth and flexibility in this respect; yet, implementing features such as programmable shading can be problematic since viewing them is dependent on the limited capabilities normally found in client viewing software, usually a web browser plug-in or a stand-alone player. Other proprietary, real-time 3D viewing formats have already come and gone. Shockwave 3D and other applications attempted to provide cross-platform solutions to web-based 3D interaction. But although they addressed visualisation requirements with varying degrees of success, they have not achieved the fundamental goal of real-time photorealistic representation.

High dynamic range image-based rendering and texture mapping techniques facilitate extraordinarily realistic polychromatic lighting and reflection effects. Indeed, such methods represented a huge leap forward for 3D computer graphics. However, whilst research has demonstrated the possibility of applying the stunning potential of this technique in real-time, it has yet to be implemented in commercially available 3D viewing environments.

The reason behind such shortcomings among currently available 3D viewing tools is neither a lack of ambition nor a miscalculation of user needs on the part of these software developers. Until very recently, the culprit could be found in the combination of the capabilities of computer graphics processing, operating systems and 3D graphics application programming interfaces (APIs) including Open Graphics Library (OpenGL) and Microsoft's® DirectX®. However, I can offer some hope that vastly improved options for 3D visualisation may be on the not-too-distant horizon.

Computational advances, such as multiple processors, 64-bit addressing and increasingly powerful graphics cards in consumer level systems are increasing the potential to exploit new, advanced real-time rendering features available in OpenGL 2.0. Particularly exciting is the new shading language (GLSL) functionality offered in this widely used, cross-platform graphics API. Because sufficient processing capability has finally become available, these programmable shading features will allow real-time representation of complex surface textures. For example, precise diffuse colour and specular colour image maps can be layered and combined with advanced lighting effects – such as bump-mapping – to create highly realistic results. Additionally, an advanced GLSL lighting method known as 'per pixel shading' offers superior realism in object illumination that is both independent of polygonal mesh resolution, and quite unlike the traditional per-vertex approach. Using these advanced features, it will soon be possible to authentically render complex and challenging materials such as velvet, carved marble or distressed gilding, in a real-time environment accessible to consumer-level computer users.

These improvements in real-time rendering will help us realise our ambition to present high-fidelity 3D data in conjunction with authentic textures and material shading in a live viewing environment. There will no longer be a specific barrier, other than our imagination, to developing a new generation of visualisation tools that can fully represent the richness of the visual, geometric and time-based data that can be acquired from artefacts.

I've waited a long time for a truly capable tool, and in the spirit of 'if you want something done…', work on such an application is currently underway at the University of the Arts London. As part of the SCIMod project, we are striving to develop this new visualisation environment that can meet the high-fidelity requirements of the cultural heritage sector. For more information on SCIMod, contact Dr Angela Geary, SCIRIA Research Unit, University of the Arts London (*a.geary@camberwell.arts.ac.uk*). ■

More at www.viznet.ac.uk/3dvisa

Featured 3D Project

CERVETERI REBORN. A 3D Experience of an Etruscan Necropolis

by Luciana Bordoni and Sandro Rubino

What makes a virtual entity believable and perceived as objective? To answer this important question one has to consider a number of factors, last but not least communication. The aim of the virtual representation of the site comprising the Etruscan necropolis at Cerveteri, the ancient Caere, that the Italian National Agency for New Technology, Energy and Environment (ENEA) has created in collaboration with the Soprintendenza Archeologica del Lazio, was to contribute to the ongoing debate on the **perception** of a virtual environment. For a simulated, virtual environment to be **credible**, the behaviour of all the objects contained within it must conform to the normal laws of physics to which we are accustomed. A virtual space is above all a space for information and communication, in which the concepts of proximity and distance are emptied of their formal aspect in order to bring out their communicative content. In virtual space, the time variable also takes on a different dimension.

Fig. 1. Cerveteri terracotta slab with a figure of a warrior. © Museo di Cerveteri.

The experience presented here was concerned with the reconstruction of a terracotta slab decorated with a painted figure of a warrior from the late sixth/early fifth century BC in the Museo di Cerveteri. The warrior is wearing a red chiton decorated with a disc cuirass held at chest level by four leather straps, and Attic helmet with a tall plume. The figure is of particular interest, as it is depicted pointing a long spear – whose ends are not preserved – towards the ground. This artefact is a first-class archaeological source for understanding the artistic culture that flourished in the late archaic period in Caere. The fine style of the painting and its unique iconography have attracted much scholarly interest, giving rise to reconstruction hypotheses. These have resulted in a 3D reconstruction of the slab in the context of its environmental setting. The aim was to explore the narrative of the space in which the warrior slab was placed within the context of its surroundings, taking into account archaeological evidence and other sources against which the reliability of the reconstruction could be verified. In this case, two reconstruction hypotheses – the underground tomb and the temple – were taken into consideration as architectural context for the slab. The in-depth historical research by experts in this area, led not only to the reconstruction of the temple, but also to the reconstruction of its archaeological surroundings. This study required ongoing collaboration between computer scientists and humanities scholars. The software tool chiefly used was 3D StudioMax 5.

Fig. 2. A hypothetical digital reconstruction of the Cerveteri terracotta slab with a figure of a warrior.

The incomplete slab was a starting point for formulating hypothetical reconstructions. The first suggests a warrior killing his adversary, and the second a ritual dance. First, the terracotta surface was restored and parts of the image coloured in. It was also necessary to consolidate the damaged parts and compensate for the elements that although missing were indispensable for the slab's virtual reconstruction in accordance with the scholars' hypotheses.

The digital model of the slab involved the following processes: integrating the missing parts, removing the slab's imperfections, reconstructing the missing parts and completing the background. The holes anchoring the slabs to the wall were also restored in accordance with the presumed original scheme of two holes per slab in the upper portion of the composition, arranged in an approximately symmetrical fashion, and the complicated pattern of *craquelures* was reintroduced for a clear distinction between the original and the digital.

The main objective of the project was to place the warrior slab within its setting, taking into account the archaeological evidence and document sources against which the reliability of the elements used in reconstruction of the environment can be verified. The geometric model of the temple was derived from the sources and from the model of the Temple A in Pyrgi, produced by the Istituto di Etruscologia at Rome's Universita della Sapienza, on display at the Museo di Villa Giulia.

The three-dimensional reconstruction of the temple was followed by the discussion as to how the warrior slab might have been set within such a space. By reconstructing buildings no longer in existence, the modelling of a historicised setting has allowed for recreation of the destroyed past, leaving room for further historical reconstruction. The hypothetical placement of the slab in the temple was based on the House of the Vettii in Pompei, which may be dated to the mid first century AD. Our work was modelled on its painted decoration: the elegant painting in the atrium and the renowned mythological frescoes in the adjoining peristyle.

Our work provides a base on which a more complex virtual heritage simulation will be built. Integration of sound, touch and other aspects of spatial perception that significantly extend interactivity, is our next objective. K. E. Steiner and J. Tomkins (2004) believe that keeping enough room for exploration that is free from interactivity, is key to achieving immersion and engagement. The next step will be the introduction of virtual humans to increase the realism of architectural models. This scenario, based on historical sources, will add a new dimension to our understanding of the past. Our cultural heritage is not confined to the visible architectural remains. ■

More at www.viznet.ac.uk/3dvisa

NEWS AND EVENTS

3DVisA Student Award 2007 Call for submissions

The JISC 3D Visualisation in the Arts Network (3DVisA) invites submissions to the 3DViSA Student Award 2007. The award will be for an essay on an innovative application of 3D computer graphics to any area of study in the Arts and Humanities. The winning essay will be published by 3DVisA and the author will receive a bursary of up to £300, sponsored by the AHRC Methods Network, to attend a UK conference of his or her choice. The 3DVisA Student Award is also sponsored by Intellect and Prestel publishers.

This award will be made to an undergraduate, postgraduate or Ph.D. student currently registered in the UK. The completed essay and application form must be submitted by 1 October 2007. The winner will be announced by 14 December 2007 and the winning essay published in the 3DVisA Bulletin in March 2008. Further details are available at *www.viznet.ac.uk/3dvisa.*

3DVisA invites you to:

ATTEND *INTERSECTIONS IN VISUALIZATION PRACTICES AND TECHNIQUES,* a workshop organised by VizNet, the UK Visualization Support Network in association with 3DVisA, Loughborough University, Leicestershire, UK, 17-19 April 2007. Further details at *www.viznet.ac.uk*.

THE BODY AND THE MASK IN ANCIENT THEATRE SPACE, an interdisciplinary symposium, Handa Nô Studio, Royal Holloway, University of London, Egham and King's College, London (Strand Campus), 5-6 May 2007. Organised by King's Visualization Lab at the Centre for Computing in the Humanities, King's College London and the Department of Classics and Ancient History, Durham University as part of an AHRC -funded project. The programme includes a demonstration of 3D motion-capture to record movements of performers and placing them in virtually realised ancient theatre spaces, and a performance by the renowned Japanese Nô performer, Matsui Akira. For further details contact *margaret.coldiron@durham.ac.uk*

Courses in *3D LASER SCANNING IN THE HERITAGE FIELD and LASER CLEANING IN CONSERVATION*, National Conservation Centre, Liverpool. For dates and further details please contact *conservationtechnologies@liverpoolmuseums.org.uk*

SIGGRAPH 2007, FACE TOMORROW, the 34th International Conference and Exhibition on Computer Graphics and Interactive Techniques, Conference 5-9 August 2007, Exhibition 7-9 August 2007, San Diego Convention Center, San Diego California, USA. Further details at *www.siggraph.org/s2007/index.html*

DRHA 2007, Digital Resources for the Humanities and Arts Conference, Dartington College of Arts, Devon, UK, 9-12 September. Further details at *www.drha.org.uk*

CONSULT The London Charter. *Comments are invited on the proposed London Charter for the Use of 3-dimensional Visualisation in the Research and Communication of Cultural Heritage*. The *Charter* is available at *www.londoncharter.org*

PARTICIPATE in the 3DVisA Survey of the needs of the 3D community. We would like to hear from all involved in the creation and use of 3D visualisation. The survey is available online at *www.jiscmail.ac.uk/lists/visa-3d.html*

CONTRIBUTE to 3DVisA resources. Submissions of academic papers and profiles of projects that involve 3D visualisation are invited. Please contact *anna.bentkowska@kcl.ac.uk* for further details.

JOIN 3DVisA

at www.jiscmail.ac.uk/lists/visa-3d.html

URLs in this Issue

ENEA, Centro Ricerche Casaccia, Italy – *www.casaccia.enea.it*
Game On – *www.gameonweb.co.uk*
HEART – *www.heritagecity.org*
London Charter – *www.londoncharter.org*
Open Graphics Library (OpenGL) – *www.opengl.org*
Microsoft's® DirectX® – *www.microsoft.com/windows/directx/default.mspx*
QuickTime® – *www.apple.com/quicktime*
Spatial Metro Project – *www.spatialmetro.org*
UNESCO World Heritage (with links to World Heritage sites on Google Earth) – *http://whc.unesco.org*
Urban Modelling Group at the University of East Anglia – *www.urbanmodellinggroup.co.uk*
Virtual Reality Mark-up Language (VRML) – *www.web3d.org/x3d/specifications/vrml*
VISA-3D List – *www.jiscmail.ac.uk*
X3D – *www.web3d.org/x3d*

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Who's Who in this Issue

Luciana Bordoni has a degree in Mathematics from *La Sapienza* University of Rome. Her specialist area is in Control System and Automatic Calculus Engineering. She has been working for the Italian National Agency for New Technology, Energy and Environment (ENEA) in the field of data processing, databases, information handling since 1980. Her present research activities are in the area of artificial intelligence and cultural heritage.

Angela Geary is Director of the SCIRIA Research Unit at University of the Arts London. Her research involves interdisciplinary collaboration spanning the arts, science and technology. Her current interests include 3D digitisation and visualisation techniques, analysis and visualisation of structural stress in stone sculpture and multi-sensory computer interaction. In 2005, she led the VEMDis™ team to win a finalist's prize in the National Research Councils UK Business Plan Awards for the development of a novel augmented reality display device for museums. She is a consultant and advisor, providing specialist 3D imaging services, to several national museums and cultural heritage agencies including the Museum of London, the National Trust and Historic Royal Palaces.

Robert Laycock is a Senior Research Associate in Computer Graphics at the University of East Anglia, Norwich. Motivated by the laborious process traditionally employed in the creation of urban models, he investigated methods to rapidly generate three-dimensional environments. In particular developing novel algorithms for the automatic generation of virtual urban environments from GIS data and enhancing the fidelity of these environments via the integration of ground level images. Working within the Urban Modelling Group at UEA, Laycock investigated new ways in which offline rendered movies may be exploited. This entailed the research and development of new human computer interaction techniques including the incorporation of haptic feedback devices for both navigation and exploration of virtual worlds.

Stephen Laycock is a lecturer of Computer Science at the University of East Anglia, Norwich. Laycock primarily teaches interactive computer graphics, virtual environments and computer programming. His research focuses on geometric algorithms and techniques to enhance the use of haptic (force) feedback devices in a three-dimensional computer-generated environment. Recent work includes the simulation of deformable tools which may be manipulated using a haptic feedback device. This work has important applications in virtual training where a user can perfect a skill in a safe and realistic environment.

Sandro Rubino read Conservation of the Cultural Assets at the School of Humanities, *Suor Orsola Benincasa*, at the University of Naples. In 1999 he worked with archaeologists at the University of Caen, France, excavating a Roman site in the city of Vieux (Caen). His research is concerned with the applications of computer technology in archaeological research, with special interest in the GIS (Geographical Information System) and GPS (Global Positioning System) systems.

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