Digital Ornament

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Abstract

Gaming software has a history of fostering development of economical and creative methods to deal with hardware limitations. Traditionally the visual representation of gaming software has been a poor offspring of high-end visualization. In a twist of irony, this paper proposes that game production software leads the way into a new era of physical digital ornament.

The toolbox of the rendering engine evolved rapidly between 1974-1985 and it is still today, 20 years later the main component of all visualization programs. The development of the bump map is of particular interest; its evolution into a physical displacement map provides untold opportunities of the appropriation of the 2D image to a physical 3D object.

To expose the creative potential of the displacement map, a wide scope of existing displacement usage has been identified: Top2maya is a scientific appropriation, Caruso St John Architects an architectural precedent and Tord Boonje’s use of 2D digital pattern provides us with an artistic production precedent.

Current gaming technologies give us an indication of how the resolution of displacement is set to enter an unprecedented level of geometric detail. As modernity was inspired by the machine age, we should be led by current technological advancement and appropriate its usage. It is about a move away from the simplification of structure and form to one that deals with the real possibilities of expanding the dialogue of surface topology. Digital Ornament is a kinetic process rather than static, its intentions lie in returning the choice of bespoke materials back to the Architect, Designer and Artist.

Introduction

Gaming and CAD visualization software share a diversity of program usages, each area has its selective methodology on which parts of a program it adopts, a particular modeling tool, a rendering capability or its animation capabilities. Software providers have made provisions for all areas of production, and this has in turn promoted an eclectic overlap. Advances in gaming resolution will figure heavily in the forthcoming years, leading software provision into a sophisticated dialogue of increased topology. Historically, decoration disappeared from the early modern designer’s lexicon, today advanced modeling and CNC technologies will allow ornament back onto the center stage. There is considerable potential for the resurrection of surface (3D) texture/decoration within architecture, art and design.

This area of research originated from a student request to create a meshed screen for a final year CAD visual. The easy option was to create a checker transparency map to represent the mesh of the proposed screen, but there were issues with that method of virtual representation. A checker transparency
would create the effect of a mesh on a planar object, but it would not be able to carry the shadowing properties of a modeled mesh object. The question arose that there must be a way of harnessing the technology of 2D visual representation, in this case the transparency map, to create a physical artifact rather than an illusion, and there must be a quicker method of construction. There always is.

The appropriation of the visual 2D representation into a 3D model is the aim of the current research, and to explore and highlight the possibilities available. With such a large resource of 2D maps created for image production, the possibilities are endless - always a positive thing for creativity. The basic toolbox of the render engine is not an exclusive CAD Visual element; it appears in many genres of virtual representation, employed differently per incarnation. Gaming and animation are examples of the differing usage but they employ a different working methodology to that of the CAD visual.

Despite the differences between CAD visual elements animation and gaming, they do share the same rendering components in the creation of the desired effect. The research breaks down the complexity of usage into the bare components. From its early origins in 1976, [this is as early as it gets for the modern day Computer] the texture map has become not just an image-based activity; it has developed the potential to generate complexity of detail once unimaginable. Is it time to revisit the role that visualization, gaming and computer animation have in the real world?

The world of computer generation is often referred to as the virtual world; there is no reason why some of the advancements of the virtual world cannot be appropriated to become physical objects. Today, the texture map is far from being just a mere image-based activity; it has evolved into a powerful tool for the geometric displacement of topology. This introduces an exiting era of unparalleled detail, which in itself is quite ironic, considering the checkered history of virtual representation.

**Texture Maps**

Why texture map? In the quest for more realistic imagery, one of the most frequent criticisms of early-synthesized raster images was the extreme smoothness of surfaces — they showed no texture, bumps, scratches, dirt or fingerprints. Realism demands complexity, or at least the appearance of complexity. Texture mapping is a relatively efficient means to create the appearance of complexity without the tedium of modeling and rendering every 3D detail. (Heckbert 1986).

Texture mapping is in essence an automated process to replicate a complexity of surface. It is an important historical precedent from which we can get the first insight into the imaginative processes developed by the early pioneers of textural reality. To date, the technique has remained a visual representation that avoids the tedium of physically modeling the surface of 3D objects. In the early days of virtual representation, a toolbox was formed to enhance the plain surfaces of the computer 3D model. This was very much an image-based activity, employed to produce an effect of realism.
In 1986, Paul Heckbert of Pixar surveyed the use of texture mapping, and considering the hardware and software available at that time, it was no surprise that there was so much methodology developed in the world of visualization. Over a short 10-year period the major components of today’s rendering software environment were formed. Between 1974 and 1985 texture mapping evolved from being a singular method of mapping color onto a 3d object, to a multitude of user-defined attributes. Figure 1 helps to illustrate and define the factions of the typical rendering palette. It is interesting that this collection of ‘effects’ are based on the original collection of advancements listed by Paul Heckbert in 1985, and are very much still in use in today’s rendering and animation programs.

- Surface Colour [Ed Catmull 1974]
- Specular reflection [James Blinn 1976]
- Bump mapping [James Blinn 1978]
- Transparency [Geoffrey Gardner 1985]
- Diffuse reflection [Gene Miller 1984]
- Surface Displacement/ shadows maps [James Kajiya 85] (Heckbert. 1986).

### Bump Map Evolution

Jim Blinn’s paper “Simulation of Wrinkled Surfaces” published in 1978 is an iconic paper documenting his research [invention] into the making of what is widely known now as a bump map. It signaled for the first time a progressive movement towards the appearance of true complexity and realism in the CAD environment. Pre 1978 visualization and gaming had lived in a flat raster based world.

Blinn employed a technique that mapped a grayscale 2D image to the surface of the 3D object. The grayscale map is employed with a lighting module to determine the height of the image based displacement, the white end of the grayscale determined the height of the displacement and the arrangement, and graduation of the source image file determined the overall effect of displacement of the surface. In essence, the grayscale map is a height map used by the render engine in displacing the pixels in the image rather than displacing the geometry of the actual object.

![Figure 1. From left to right the application of a color map to a sphere.](image1)

![Figure 2. Bump mapping example.](image2)
Displacement mapping

Displacement mapping is a further advancement in Blinn’s technique. It is directly related to bump mapping in that it also uses a height map to model surface perturbations. The difference, however, is that displacement mapping actually modifies the surface geometry, whereas bump mapping only affects the normal vectors. In other words, displacement mapping adds geometric detail to the mesh (Nuydens 2004).

Polygon displacement can provide us with physical [virtual] surfaces of geometric complexity. It is true that the level of processing power, along with the complexity of mesh needed to gain a detailed object, can be overwhelming, especially for animation and gaming. However, the evolution of the bump map into displacement is the initial stage of a process that automates the modeling of highly detailed objects; a process that does away with the tedium of having to model every little detail. Conceptually, it can provide unprecedented levels of detail.

Our research was an evaluative study exposing the differences between the bump map and the Displacement map. Figure 3 above shows the differing topological displacement of a grayscale map on a simple elliptical sphere. The bump map on the left is heavily reliant on not only the grayscale map but on the lighting employed to define the image displacement. Bump mapping works well as a means of imaging topology but the representation becomes more obvious the closer you get to it with the camera view. A Bump map resides somewhere between image and surface.

The image on the right is computed using the displacement map method. The displacements are worked out by physically displacing the geometry of object to that of the map. In order to keep an effective workflow the actual displacement is not fully employed as physical polygon model, rather it acts as a geometrical code at the rendering stage. The difference in surface topology is self-evident; the displacement appears physical rather than an effect and at close quarters, the sphere retains accurate topological detail.

Displacement baking

Displacement baking is a term used to describe the conversion of a displacement map to polygon model. It bakes the image representation into a 3D polygon model. Further research located the appropriate program to extract an image-based mesh displacement. Out of the traditional stable of programs 3D max, Form Z, 4D Studio, Rhino 3D and Maya [there are many others] Maya, the animation and game-modeling program, offered the most potential.

The ‘Displacement to Polygon’ feature gives you the ability to bake the displacement-map and lets you determine the location of displacement-mapped surfaces so you can animate correctly.
This feature lets you see the effect of the displacement in the modeling views very quickly. For example, a displacement map is used to create a mountain range on a NURBS ground plane and if you want to animate a helicopter flying through the mountains. The conversion helps you visualize the mountain range as you animate. You can always delete the polygonal model later (Alias Maya Manual).

The creation of a polygon model through image displacement is a powerful concept and offers interesting opportunities in the creation of complex digital models. In traditional usage, the baking of the displacement is an important part of image-based production.

Developing Displacement

Top2maya

Further investigation into the process of displacement methodology unearthed a scientific appropriation of Maya’s Baking process. Rob Gillespie created an appropriation of the displacement feature in 2000, by harnessing the displacement-baking feature of Alias’ Maya for the visualization of cell structure. This was an interesting diversion of bump map technology; it was worlds apart from video gaming, children’s animation and architectural visualization.

Top2maya is a program written in MEL script, which changes 2D topographical maps into three-dimensional models and images. This script does this by changing an image into grayscale, then displacing the pixels according to their intensity value. White gets displaced the most on the y-axis, while black does not get displaced at all. The resulting models make it easy to visualize the surface (Rob Gillespie 2001).

Top2maya gives us a valuable insight to the possible uses of displacement technology. This direct appropriation of visualizing technology for use in a scientific environment has provided scientists with the ability to represent the microscopic form in 3 dimensions. While this is largely still an image-based activity it relies on an accurate scientific formula to reproduce the closest possible representation of cell structure. Top2maya offers us the initial stage of a tool that can accurately translate imagery into displacement maps. It automates the process of image to displacement to polygon model very efficiently and is extremely user friendly. It is limited to the plane as a means of displacement, but with consultation, this script can be developed to provide the ability to map to spherical and irregular objects.

ZBrush

The concept of baking as a process offers a path into the physical construction of complex computer topology. Software products such as Zbrush by Pixologic, Inc. deal specifically with the sculpting of high-
resolution models in real time. It does this by layering displacement and normal maps on top of what are, at first, low polygon constructions. The baking method allows consolidation of detail at each application of texture and it can build on the displacement process to create a complex rendered representation of displacement detail.

Yet another way that ZBrush can make use of ‘displacement maps’ is to actually convert the displacements into geometry. This allows you to recreate a high-resolution mesh from the displacement map, and then continue sculpting high frequency detail. The high-resolution model can then be used in your ZBrush scene or used to create a new displacement map for rendering elsewhere. This combination of maps can then be taken into an animation package or game engine and used with a low-resolution model of the model, the baked normal and displacement maps are then used as skins for the polygon models, to achieve extremely high levels of visual realism (Zbrush. Pixelogic, Inc).

A new age of Ornament?

Digital Ornament could enter a new age of ornament informed by contemporary architectural practice. Once again, there is a search for new challenges in the perception of detail. CNC production techniques allow us to fabricate in exacting detail an artifact, and with the development of this technology, there is great potential in expanding the dialogue of making. The production of physical objects is enviably the goal of this research project; its process is locked in the destiny of the 3D mesh representation to become a real object with a highly detailed surface.

Historically, a wonder of natural systems has served scientists and creative designers well. For example, Leonardo da Vinci’s studies of anatomy and the botanical formed the basis for both his art and his interventions. This contrasts sharply with the first half of the 20th century when the motorized machine became the model for architecture, as
espoused and illustrated by Le Corbusier in his writings. Placing man’s own interventions at the apex of innovation automatically circumscribes the potential of architectural design and built form, as design becomes largely the intent of the single polished set object (Weinstock 2004).

With the realization that what is created on screen can no longer be regarded just as a visual representation, this research has progressed from harnessing the potential of the computer in the making process, to a wider philosophical question. The potential of displacement to object is a powerful and exciting expression of modern technology. The emphasis must also be placed on a desire to move forward from the traditional Corbusier model of machine production, away from the simplification of structure and form into one that deals with the real possibilities of expanding the dialogue of surface. There is a call for a new age of ornament that expresses contemporary practice and relates to modern practice.

Historically mankind has expressed technological advancements through the process of making. There are distinct periods in history that have left us a rich creative legacy of the development of mankind. The agricultural revolution, the industrial revolution, the machine age have all left us with architectural expressions of time through the built form, along with a rich catalogue of artistic and sculptural artifacts. These artifacts clearly express the advances made within each distinct period and provide a rich source of inspiration for today’s designer.

A return to ornament is a contentious issue in that it flies in the face of a dominant strain of early modernist values, and because recently minimalism. The white undecorated planar tradition of the International style persists in some quarters within current architectural and interior practice. Historically, as early as the 1950’s one of the main champions of modernism and minimalism, Corbusier, moved away from pure minimalism to a more expressive personal style.

Some former champions of the International Style, including Le Corbusier himself seemed to be setting its principles aside in a search for a more personal mode of expression. His amazing pilgrimage chapel of Notre Dame du Haut at Ronchamp in France (1950) was an intriguing combination of functionalism and pure sculpture: it puzzled critics who saw its bizarre, hybrid structure as a betrayal of the principles of modern architecture. (B. Risebero 1979)

We too could adopt a personal style that is reflective of our ever-changing

Figure 7. Our domestic interiors will return to this?
environment. The harnessing of the technology I described earlier is, and will, permit and encourage this adoption.

With even the forefathers of modernism able to set their principles aside and be driven by the creative process, it is surely time that we ourselves explore the potential of digital ornament without the traditional cries of: ‘Decoration for decoration sake, Craft doesn’t respond to anything, its mere decoration’. To a certain extent, mere decoration can be a dangerous aesthetic. Cast yourself back to the Victorian era, a time of material function characterized by an excess of decoration and ornamentation. It was a time of theatrical spaces that overloaded perceptions of space. With the programmatic stripping of all ornament and detail of surface, modernism has also stripped the theatre of surface.

There is a current explosion of expressiveness within the appropriation of digital design within Architecture. The 2004 Venice biennale entitled ‘Metamorph’ was testament to a broad scale move away from more traditional architectural production to the digital practice of Architectural design. Architecture has developed digital technological advances, appropriated their usage and re-interpreted the methodology of architectural production. Digital Ornament is a further appropriation of Digital Design, highlighting that precedents in form making need not be employed purely at an architectural scale.

Existing precedents

Architectural Case study - Caruso St John Architects

Lace Façade detail: Caruso St John, Nottingham Contemporary Art Centre

Ornament returns in Caruso St John’s architectural practice, a practice formerly associated with modern, minimal design. They have shown an interest in the return to ornament through digital appropriation of ornament. The process is an image-based appropriation; simple in concept, it offers a high level of detail. A sample of lace will be scanned, turned into a 3D computer model and molded into the pigmented, pre cast concrete panels forming the elevation of the centre. Simple in its concept, it signifies a positive development of ornament.

“We’re trying to start to express more formally the idea that interpretation is a very powerful thing. Interpretation of tradition has always been how you made art and architecture, it’s only really since the 1950’s that this idea of pure

Figure 8. Lace Façade detail: Caruso St John, Nottingham Contemporary Art Centre.
Caruso St John Architects’ usage of digital surface ornament offers us one precedent as to how the usage and application of digital topology can develop in contemporary architecture. Their appropriation of the past and its interpretation through a digital process is an architectural invention and is consigned to the building façade, but it shows a renewed interest in the revival of ornament as a means of architectural expression. It feeds on the past rather than consigning history to the past and provides us with evidence of a philosophical move back to the use of highly detailed ornament.

**Art case study - Tord boontje**

Tord Boontje’s current work is incredibly tactile and unashamedly decorative, it’s all about the physical allure of materials and ornament—lace, crystals, and flowers, reacting against the austerity of his earlier work. “I simply got bored; to me it’s more interesting now to work louder, more visible decoration. I want to challenge the Conan shop.” Boontje’s genius has been to tap into the sensory appeal of handcrafted historical ornament, but repackage it for the computer age, exploiting the latest high tech processes to produce domestic objects with a craft aesthetic at an affordable price (L. Jackson. 2004).

Within the freedom and autonomy of the art practice Tord Boontje is at the forefront of digital ornament. He has produced a highly influential solo exhibition called *Happy Ever After*, held at the Moroso gallery, Milan 2004. The exhibition was also exhibited at the Moss gallery in New York 2005. His philosophical stance is a progressive move away from minimalism towards an expressive use of digital ornament.

Decoration is not a negative term for me. The original ideas behind Modernism got hijacked somehow and the term Modern has come to mean something that is very stylistic or minimal—something devoid of the original, important emotional qualities of Modernism. I try with my work to bring back sensuality and human qualities in the spaces in which we live and the objects with which we live. And to do it in intelligent, efficient, and affordable ways. In a funny way, what I’m doing is very modern. (T. Boontje 2004).
Conclusion

The initial research proposal stemmed from the appropriation of the texture map into a tool that could automate the creation of complex forms, such as a mesh screen. I have developed the argument from the theoretical process to the wider issues surrounding ornament, because as the findings were discovered it quickly became apparent that the development of such a tool had exciting possibilities for the development of digital ornament.

The context of the research ultimately lies in the appropriation of visualization software. The development of the bump map into the displacement map is cited as a significant advancement in the generation of complex physical forms. At the outset of the research exercise, it was important to research and form a new methodology for the development of digital ornament. The research into the evolution of the bump map identifies areas of appropriation that can be utilized to create complex digital displacements, and builds a theoretical and practical avenue of future research development.

Rob Gillespie’s Top2maya provides a precedent to the implementation of a tool-based approach to the displacement feature within Maya. Developed in 2000 for use with a very diverse scientific clientele, its application provides us with the beginnings of a user-friendly interface for the creation of complex polygon forms. The development of this existing technology would take us another step forward in the automated application of virtual surface displacement. With consultation, it is hoped that this script will be developed in further research.

If we drop the premise of rendering, in favor of the physical displacement model, Z brush’s operational concept offers an insight into the methodology need to gain a high-resolution topological displacement. The limitations of the polygon mesh have always been a major unsolved question within the research, but with the arrival of a new era of higher definition gaming machines, such as the X Box 360 and the Playstation 3, a new opportunity can be seized.

Development and investment in programs such as Zbrush will increase along with the resolution of gaming and there are substantial funds being invested in the realization of High-resolution gaming. The appropriation of multiple use, a transferal of technology for use in the production of the artifact has exciting possibilities not only for architecture but also for the manufacturing industry as whole.

This development of increased detail currently resides in virtual space, and there is no reason why we cannot appropriate it to the physical world. You cannot compete with the beauty and diversity of the natural world, but today you can reference diverse technology within the creative process of making.

The creation of a prototype to test Digital Ornament is the path of future research. As a method of creating form, rapid prototyping and CNC machinery is still quite limited. That said, it would be nice to make CNC machines work a little harder for their keep, and by engaging in high resolution tasks we would be getting the maximum development of CNC production. Tord Boontje and Caruso St John are architects who further the understanding of how we may creatively employ CNC fabrication techniques.
Digital Ornament is an expression of the technology at our hands today, a celebration and a proposal of advanced usage. Quite possibly, in the wrong hands it could become a return to the over embellishment of surface, but until we break with tradition, namely modernist tradition we will never realize the potential of Digital Ornament. Ironically the provider of this technology is computer gaming. For the short period it has existed it has had a checkered history, associated solely as a leisure activity of the young and not so young, with little or no academic merit. In a twist of irony, the gaming industry provides us with the opportunity for creating unprecedented detail in our physical world.

References

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Illustrations

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