Digital Light

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The cover is a visualization of the book's text. Each column represents a chapter and each paragraph is modeled as a spotlight. The colour reflects an algorithmic assessment of the paragraph's likely authorship while the rotation and intensity of the spotlights are based on a paragraph's topic ranking for "digital light". It was made with Python and Blender. © David Ottina 2015 cc-by-sa

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CHAPTER 8

Simulated Translucency

Cathryn Vasseleu

We perceive translucency as the intermingling of matter and light within media. All materials except metals are translucent in varying degrees. Their capacity to diffuse light inside them has many magical and supernatural associations. Translucent substances have an inner glow that can imply interiority, or even the evanescent presence of an embodied soul. The ability to emulate these subtleties is a goal of photorealistic digital image synthesis. To date the best results have been achieved using an appearance modelling approach. Appearance models are algorithms for rendering the appearance of all kinds of materials, including those with varying degrees of translucency, such as ocean water, tree leaves, milk, marble, paper and skin. The aim is to produce a computer model that approximates the appearance of an object made of a translucent substance so closely that the photorealistic rendering elicits more or less the same visual response as to a photograph of the physical object. What matters in appearance modelling is that the computer model's formulation process is not detectable at a sensory level. How then might we begin to aesthetically acknowledge or engage critically and creatively with its synthetic inner glow? As will be elaborated, the difference that cannot be seen lies within the sensibility of simulated translucency.[1]

Models for depicting photo-realistic translucency are just one of many light rendering techniques, including shadow casting, ray tracing and radiosity. These

programs do not simulate the way light is recorded in photosensitive media. They simulate the way light rays interact with shapes, material surfaces and with each other. Light rendering programs raise questions about how their process can be read in the context of multiple codes of realism (pictorial, three-dimensional, photographic and cinematic, video, etc.). However, the aspect of photorealistic image synthesis that most relates to the sensibility of simulated translucency is that in the digitally rendered image the signs of realism are not written in light. Light is written in code.

Appearance models render the appearance of different materials naturalistically, based on codified empirical indices of their optical characteristics. Whether simulations appear realistic, or life-like, because they capture and reconstruct the essential physical arrangement of the empirically measurable world, or whether perceptual processes and/or discursive practices determine our experience of simulated photorealism, are well-worn topics of debate among scientists, artists and media theorists. In order to consider how we *get* a model of life-like translucency (both technically and as a perceived effect), it is necessary to take a more specific approach. This first involves distinguishing translucency from transparency. Transparency was pursued as a guiding characteristic and perceived effect of Modernist aesthetics. Within Modernism and subsequent related movements, translucency has been understood in relation to transparency, defined as either an optical or a perceptual quality. With alternative ways of understanding the unique consistency of translucent media in hand we can, in turn, elaborate on the perceived translucency of a computer model.

Differences Between Translucency and Transparency

A transparent substance is one that is capable of transmitting light as though there is no intervening matter. Transparency, understood as a sensibility of both eye and mind, is the condition of optical surety and abstract clarity, secured by light passing freely though the concrete. As such transparency has aided idealist philosophy in its articulation of metaphysical vision, the spiritual soul and metaphoric illumination (through a light that illuminates matter but is refractory to incorporation).

In modern thought, matter's capacity to transmit light in this way became a key factor in the explication of aesthetic concepts in painting, photography, film, sculpture and architecture. For example the 'see-through' effect took a luminous turn in art criticism that championed transparency in construction and critical reflection. Understood as the experiencing of things 'being what they are' (Sontag 1966:

13–14), transparency was a liberating, luminous clarity. It applied to minimalist art that is open to, and addressed directly to, the transformative exercise of our senses, rather than thick with hidden crafting and meaningful content. Transparency was also an emblem of the social, corporate and political ideals of structural and operational transparency, or openness. I will offer only the briefest sketch of transparency here, setting aside discussion of the 'myth' of transparency that haunted Modernity (revealed in all its opacity by Breton, Benjamin and Duchamp).[2]

Architectural transparency was, in its material sense, a guiding construction principle of Modernism. At its simplest, a fascination with the space-defining properties of transparency was translated into arrangements of glass and other materials that transmit light in such a way as to be able to see through them, or designs that involved unobstructed flows between interior and exterior spaces. The painter Robert Slutzky and architect Colin Rowe famously elucidated a distinction between the architectural interpretation of transparency in this literal sense, and phenomenal transparency, where transparency is elaborated corporeally and conceptually rather than optically (Rowe [1955–56] 1976: 160–62).[3] As well as being an inherent quality of a substance, it could also be a quality of organization. Material explorations of phenomenal transparency extended the optical characteristic to space, or the simultaneous perception of different spatial points within a dynamic field of view. The spatio-temporal complexities of phenomenal transparency were (and still are) interrogated in the exploration of fluctuating perceptual phenomena such as emerging and receding figures and ground, reflections and shadows, and implied or revealed surfaces, shallows and depths. Here transparency can apply to opaque objects, and to the semi-opacity of translucency. Both are implicated in phenomenal interpretations, as levels of transparency.

With eyes still trained on Modernism and its signature aesthetics of transparency, postmodern aestheticians initially focused on the superficiality of simulacra in their characterizations of the digital medium. Examples include Baudrillard's articulation of the play of appearances of the 'superficial abyss' and Brummett's interrogation of the 'prophylactic whiteness' or occluded interior of electronic images, devices interfaces and systems (Darley 2000: 58–77). Transparency and all it signified was obliterated by the computer interface according to such analyses. However the quality continued to figure as a key feature of 'Supermodernism', which conceives of architectural space as an 'empty medium', purposefully striving for transparency (Hans Ibelings 1998). Rather than communicating a message, supermodernist architecture works like an invisible, enveloping medium that creates a unique sensory experience.

Lev Manovich (2007) extends this aesthetics to the dissolution of personal technological devices into ambient objects in the era of ubiquitous computing. Machines disappear as they become implanted inside other objects, materials and surfaces. In Manovich's analysis transparency and translucency are regarded synonymously as the aesthetic signature of the boundless flexibility of the computer as an all-in-one meta-machine. On closer examination, his analysis relies on a difference between these two qualities. The transparency of the enveloping medium requires qualification of some kind, insofar as its aesthetic signature is not abysmal emptiness, but a comforting, sensual, enveloping shell. It is translucency, understood as a medium's capacity for incorporation and diffusion of other media, which metaphorically aids product designers' articulation of the computer as an embracing, universal simulation machine.

This brings us to an aspect of phenomenal transparency that is taken for granted. Its transparency cannot be separated from the order of matter, or a translucent materiality. The tendency of light to thicken and matter to dematerialize in translucency is associated with the appearance of a dynamic material universe. This association is made and developed in philosophical accounts of perception by Maurice Merleau-Ponty and Henri Bergson.

Merleau-Ponty gives a unique inflection to the partial opacity of translucency. He regards matter as the invisible condition of seeing rather than an obstacle to perception. For example, looking into an ornamental garden pool and observing the tiling clearly visible below, Merleau-Ponty reflects: 'I do not see it *despite* the water and the reflection there; I see it through them and because of them' (Merleau-Ponty 1962: 182). Here, the tiling materializes for the viewer in the intervening thickness of water: 'If there were no distortions, no ripples of sunlight, if it were without this flesh that I saw the geometry of the tiles, then I would cease to see it *as* it is and where it is—which is to say, beyond any identical, specific place' (Merleau-Ponty 1962: 182). Merleau-Ponty's account of visual perception is anti-optical. It runs counter to a representational view of the empirical world, or a merely physical-optical relation in which vision is based on optical surety. For Merleau-Ponty the 'see through' quality of transparency is related to a translucent materiality, not immateriality. What transparency means for Merleau-Ponty is the ability to see through the intervening thickness of media.

While Merleau-Ponty equates transparency with a voluminous translucence, he understands the dynamics of translucency in terms of mirroring:

> every object is the mirror of all the others ... I can ... see an object in so far as objects form a system or a world, and in so far as each one treats the others round it as spectators of its hidden aspects and as guarantee of the permanence of those aspects. (1962: 68–69)

Thus reflected, translucency is the condition of the apprehension of the visible as a system or universe of beings that disclose themselves in and to each other as a whole (a world of implicated figures and grounds explored in phenomenal elaborations of architectural transparency). The visible is not a formless multiplicity of perceived objects-in-general that are foremost given over to abstraction and clarification. Any seeing of an object is a participation in the translucence, that is, the whole-in-one aspect of things: 'the completed object is translucent, being shot through from all side by an infinite number of present scrutinies which intersect in its depths leaving nothing hidden' (Merleau-Ponty 1962: 68–69). The 'thickness' of translucence is not a geometrical dimension, as refined in the perspective painting techniques of the Renaissance to facilitate a more exact, artificial construction of the world. What is gathered in the intersecting voluminous spacing of translucency is the dynamic unfolding of the fabric of the world. This is conveyed in the uncontained, infinitely dispersed radiation of the visible, whose freedom in self-arrangement can be described as 'internal animation'.

Merleau-Ponty describes translucence as the shimmering clarity of a phenomenological vision anchored in the material world, but a simulation of translucent appearance is an image calculated by a disembodied model. Here translucency has a separate, non-phenomenological existence in a virtual form that is more readily aligned conceptually with Bergson's understanding of the dynamics of perception. Like Merleau-Ponty, Bergson does not regard perceptual experience as a function of a physical-optical relation between a subject and a transcendentally illuminated object-world. Instead, the appearance of the material universe is derived through our perception. In Bergson's account, material objects have independent functions and real actions, but a living body participates in creating perceptions through the momentary delimitation and isolation of a light that would otherwise pass by and remain unrevealed. The world of perception manifests its spontaneity insofar as: 'Images detach from themselves that which we have arrested on its way, that which we are capable of influencing' (Bergson 1988: 37). In this schema, a perception is a phenomenon of the same order as a virtual image. It is an effect of light that has been impeded and arrested momentarily, reflected without otherwise affecting the totality and freedom of action of matter. Reflections can appear as isolated moments

of intentionality (contracted by and limited to our interest), as when images 'appear to turn towards our body the side, emphasized by the light upon it, which interests our body' (Bergson 1988: 36). In this way images can be perceived by us as living matters, or exist and act independently without being related to an individual, illuminating consciousness.

Bergson sets out in his vitalist philosophy to dismantle the notion of an immutable universe, which he associates with an intellectual viewpoint that renders matter inert by defining it in terms of properties that accentuate its materiality (Bergson 1911: 202). By way of contrast, he describes consciousness as a translucence in which the eye is elementally in things, universalizing a pure, non-human vision in an a-centred universe of images. Bergson's mobile, iridescent consciousness is a translucence that dematerializes solidified matter and animates the universe of images and objects. The chaotic interaction of virtual influences is the source of movement in both these things.

Both Merleau-Ponty and Bergson turn to the properties of translucent media to think their philosophies of perception through. Both also invoke the dynamics of multiple mirroring when elaborating on a global translucence. On closer consideration that association needs further elaboration. Mirrors are opaque structures that reflect light without altering its clarity. Reflection alone does not account for the qualified clarity of translucency. This raises another issue: the unique characteristics of translucency that distinguish it from transparency.

Translucency is an incomplete transparency, or partial opacity. It is a liminal quality, existing on the threshold between clarity and obscurity. The 'inner light' characteristic of translucency has a thickness that is related to material consistency, not spatial depth. Optically, a translucent substance is one that is capable of transmitting light, but also causes sufficient diffusion of that light to prevent the perception of clear and distinct images through it. Instead of being entirely permeable to light, as one sees things through a clear glass window, a translucent substance is suffused throughout with a shadowless, diaphanous lucidity. The passage and containment of light creates, simultaneously, opacities in our field of vision.[4] We can see only partly, not fully, through translucent matter. Light is reflected within the material before being either absorbed or transmitted. The internal scattering of light gives rise to a soft appearance, rather than a luminous opening.

In the stained glass windows of Gothic cathedrals, translucency was used to create the impression of the unveiling of veiled truths. The iridescent beauty of partially opaque panels at once shrouded and revealed an ineffable, divine light (Von Simson 1962: 120–22). Elsewhere the ambivalence between opaque surface and

transparent opening has been employed to create a concept of a multi-natured fluid space. Translucent paper screens, a characteristic feature of Japanese architecture, were used in this way long before the concept was adopted by Western architecture in the early twentieth century. Presenting a glowing surface when closed, the screens allow direct access to nature when open (Kaltenbach 2004: 7).

Artists and architects manipulate the mutable characteristics of translucent materials to create a 'tactile' sensibility, or a sensual play between surfaces that admit light and the smooth, soft appearance of inner substance. Involving a sense of matter as much as light, translucency gives luminous contours to the material passages of inner-space. These passages are not rendered invisible or obliterated, as they are in optical transparency. Light blurs as it is incorporated and moved about within the blurring substance. Illumination takes on a sensuous character, not the clarity seen in the passage of a metaphysical light through material entities. If light figures as a connection between spirit and matter in virtually every culture, in translucency, it remains ambiguous whether light passes through or is moved by matter. While unobstructed openness is a defining characteristic of transparent relations, there are interruptions of clarity in the opaque/transparent glow of translucency, where matter has the power to admit, contain and transmit light.

A Computer Model of Translucent Media

In 2001 Henrik Wann Jensen and his colleagues at the University of California, San Diego, published a groundbreaking technique which made it possible to emulate the subtle characteristic traits of perceived translucency, such as colour bleeding within materials and diffusion of light across shadow boundaries (Jensen et al. 2001). A model that works for shiny, reflective materials such as metals assumes that light makes contact with and leaves the surface at the same position. In order to work for translucent materials the model must assume that light rays alter their position in their transmission through intervening materials, leaving the surface at a different point. These include liquid, solid and gaseous substances whose internal structure and composition scatter light, thus contributing to their visual complexity.

Optically, a significant amount of light is transported below the surface in translucent substances. Computer-models of translucent materials look completely wrong without the inclusion of this characteristic, known as subsurface scattering. The technique Jensen's team proposed made the inclusion of this characteristic practical. It worked by approximating the subsurface scattering of light diffusing through translucent materials, without having to laboriously trace the individual photons.[5]

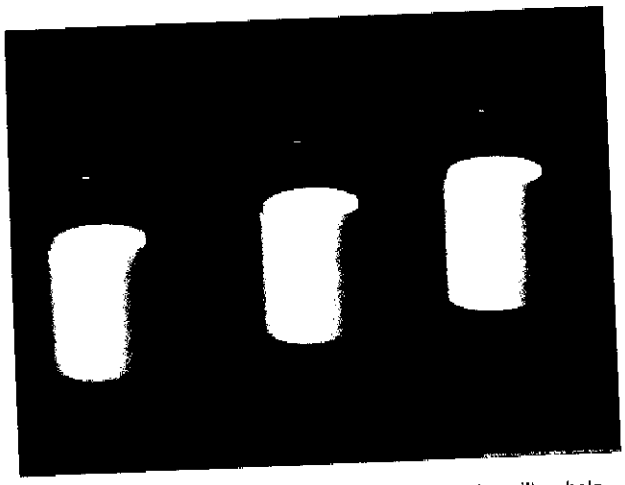

Figure 1. Three glasses of milk. From left to right: skim milk, whole milk, and diffuse milk. The skim and whole milk have been rendered using a model that takes subsurface light transport into account. The diffuse milk has been rendered using a model that defines how light is reflected at an opaque surface, which results in a hard appearance, making the milk look more like white paint rather than like milk (Jensen 2006). Courtesy of Henrik Wann Jensen.

Jensen describes his photon mapping technique as the recovery of the optical properties of matter. From this description, are we meant to understand that the likeness distilled in Jensen's model refers to a refractory substance known only by its empirically defined contours? Surely we grasp the appearance of an implied thickness and softness in a more substantive way—by responding to the image in physical terms, under the direction of the model's revision of that arrangement? Rather than posing an abstract identity, the life-like simulation of a substantive form of translucency hinges on the elaboration of an image in such a way that viewers are corporeally attuned to its material character. Jensen's team knows from experience that their task involves using a digital medium to render a materially determined 'inner light' in a visually interpretable way.

They know for example, that it is not solely the proportion of light and dark in an image, but their spatial relationships that make an object look translucent. They know that translucency affects the spatial structure of images; blurring detail, etc. Most importantly, they know that spatial organization alone does not tell us whether an object is translucent or not. Our vision is attuned to other factors unrelated to spatial layout, which influence perceived translucency (Fleming et al. 2004).

Jensen's team tests their algorithm's approximation of translucency by comparing the model's appearance with a physical model-box containing equivalent volumes and surfaces in a substantial form.[6] The visual similarity is taken as proof of the algorithm's ability to synthesize an image of an object whose translucent appearance is indistinguishable to sight from a physical translucent object. We read the object's material character from how translucent it appears in the context of its surroundings. Milk, for example, is a translucent substance that Jensen's model can replicate. Synthesized in such a way that we can identify the familiar visual surface-texture of physical translucency, a substance looks milk-like rather that looking like white paint (Jensen 2006).

Semioticians ascribed an indexical role to photography, understood as the representation of idealized physical entities. Here indexicality refers to a physically enacted connection between an object and its traces in a photographed image. Computer modelling reinvents the age-old trick of seeing by mimetic illusion. The type of index that enters into the computation of translucent appearance is the 'index of refraction', along with other parameters necessary to derive a computer model for a particular optical property. It is possible to devise models for handling all kinds of translucent substances, including the model already referred to, that can compute the parameters of milk-like translucence. Having the capacity to be fed descriptions of the fat and protein content of various milk products, it can handle the translucence of skim, regular, full fat, etc.

The experience we have of this model is regulated by au already worked-out make-up that is judged by the extent to which it achieves the intended effect; that is, a seamless visual approximation of familiar objects. Appearance modelling is based on the twin premise that images appear realistic when the model can capture, incorporate and reconstruct the essential optical-physical arrangement of the empirical world, modelled in accordance with psychophysical measurements of human powers of vision. In actuality, the model is an optical description that is designed for viewers to 'fill in' (guided by a prior carnal knowledge of milk's translucency) rather than a purely optical description.

As a circumscribed visual rendering, the image is only a partial representation. An algorithm for simulating milk-like translucency is not indicative of the mastery of phenomenal complexity. It is indicative of the mastery of the model. A model creates a unique perspective that tantalises and seduces. For example, we might experience milk in the Coca-Cola model way, as a product positioned in the company's global marketing strategy. In 2001 Coca Cola proposed a new line of dairy drinks for children under the working title 'Project Mother' (Brown 2001; Stevenson 2002). 'Milk' was not conceived of primarily as a drink made of milk. It was a beverage that was designed to capture the breakfast market because its ingredients would be judged sufficiently nutritious to win maternal approval. In other words, Project Mother wagered that appearing to be nutritious would be more seductive than being the real thing.

A computer model of a light-scattering substance is a psychophysical approximation that obviously doesn't affect our senses in the way a glass of milk does. We do not encounter the semblance as we would an 'authentic' glass of milk, whose material character is expressed in its countless corporeal manifestations; its coldness if it has been poured from a container in the fridge, forming a skin if it is hot, leaving

a white moustache on our upper lip, tasting sour because it has gone off, giving us succour as did our mother, making us sick if we are lactose-intolerant.

Just as Alfred Hitchcock is able to render milk's characteristic translucency in a suspect way in the film *Suspicion* (1941), turning its glowing interior into something equally viewable as a poisoned brew,[7] the computer model formulates its own unseen parameters of sensibility. It allows us to see exactly (enough to distinguish between skim and whole milk) in adherence with its abstracted optical-physical reality. This is the 'inherently false' reality of a formal arrangement that cannot be realized physically. We cannot experience the material nature of milk based on how exactly the model enables us to understand its milky look.[8] Jensen's model is a distillation of translucent appearance, generated by the actions of an automated, virtual light. The paths of virtual photons are calculated to lose and change position between entering and leaving the simulated material, thereby reflecting its internal structure and material makeup. In the interstices, light ceases to be a radiant beam of energy and becomes something more akin to an animated, ambient light, indistinguishable from and informative of its digital-milk environment. The characteristic optical behaviour occurs spontaneously in photon mapping but its nature is pre-scripted. The degree of luminous 'density' and 'bleeding' is calculated in advance by an invisible structuring medium that determines the image's translucent appearance. In the modelling process, the invisible ordering of a materially given, luminous sensuality is recast as a sensuality of automated light flows. Jensen activates the flow to approximate a particular visual effect. His technique of image synthesis contains the chaos of a physical universe within its complex mapping of light's movement by matter.

Despite the model's artificially imposed order it is not disorienting to a viewer. Translucent appearance is instantaneously perceived, albeit in terms of new structure. The simulation amounts to a formal re-arrangement of the visible based on the indices of 'subsurface scattering'; that is, a structure determined by codified empirical indices of optical characteristics. Thus the model creates its own invisible parameters of complexity (complex variations in the translucent appearance of different materials). An ordered appearance of soft, smooth diaphanousness is spontaneously computer-generated, but is based on a quantifiable light-scattering function that must be calculated in advance. Altering the variables can produce unexpected effects, but once scripted the actual behaviours of virtual photons interacting with virtual surfaces is fixed. As well as being motivated to act in a formally specified way, the random scattering of light is a calculated variable.

Simulated Human Skin and Its Perceived Translucency

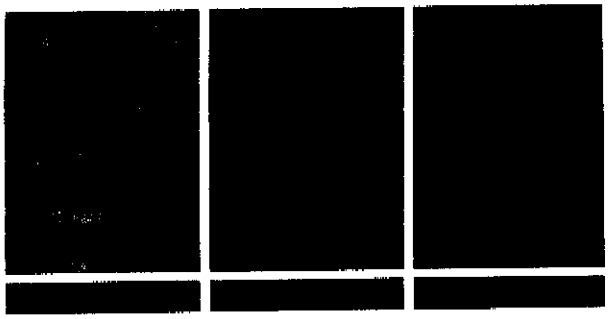

Figure 2. Different skin types simulated with model (top) compared to actual photographs of real skin samples (bottom) (Donner and Jensen 2006). Courtesy of Henrik Wann Jensen.

Appearance models describe the procedures for animating the variables that apply to the characteristic appearance of materials and media. Jensen's model for calculating subsurface scattering was quickly adopted by the 3D computer animation industry to photo-realistically render the appearance of human skin, which is a multilayered translucent substance. These multiple layers scatter light differently according to their different composition, resulting in a reddish cast to which human vision is finely attuned. More than with other materials, the slightest simulation errors are noticeable in human skin (Jimenez et al. 2010: 32). Just as the milk model can render the appearance of different types of milk (whole and skim etc.), the variables for modelling human skin can be altered to render shades of difference in its translucent appearance. The prototype for skin (skin1) was modelled, not surprisingly, as a facial close-up of a pale pink translucent cheek and fleshy, lipstick-reddened lips.[9] The modelling of various other skin-shades followed: Caucasian, Asian and African (Donner and Jensen 2006).

While the realistic appearance of simulated milk does not strike an uncanny note, the photorealism of a computer-generated actor can. The simulation of the 'inner light' occluded in human facial-skin initially exposed something of the pre-formulated 'soul' occluded in the polygonal faces of digital humans. These characters stumbled into what Masahiro Mori (1982) calls the 'uncanny valley'. Here, instead of completely identifying with a figure that appears human, audiences are repelled by traces of its robotic nature. Rather than knowing what they are looking at, viewers are disturbed by a presence they are not quite able to identify. When synthespians first appeared in 3D animations, audiences scoured their faces for traces of hidden engineering.[10] Viewers were forced to adopt an interrogative mode of perceiving while watching the moving images. Their vision was moved by practical concerns, born of an uncertainty about how they should view the photorealistic approximations of cinema screen actors they were seeing.

The simulation of human facial-skin announced a particular way of seeing the world, and with it a novel way of being (in both an existential and social sense). It

announced a new form of animated presence; simulated matter with its own built-in, manipulatable, photorealistic character. It also announced new cultural image-forms—simulated photorealistic Caucasian, Asian, African characters that posed automated racial identities with their own optically defined order.

Simulation models do not replicate the natural world. They demolish a naturalized metaphysical viewpoint and replace it with systems that generate a world-order composed of quantifiable, manipulatable results. The model for subsurface scattering results in a controlled appearance of inner light that is indicative of different types of material character. An ambiguous quality is digitally recast as a precisely differentiated spectrum of 'signature' translucencies. Disclosed according to this methodical replacement of a naturalized metaphysical viewpoint, translucency is the automatic outcome of a model with adjustable parameters that renders an empirical description as believable as the appearance of photographed physical objects.

Twentieth century avant-garde photography and cinema practices confounded indexical readings of their art by privileging material process. Critically-oriented digital-based media practices have progressively confounded readings of their art in terms of reified concepts of immateriality, abstraction and materiality. We have yet to discover procedures that render the fixed behaviour of each shade of material character seen in photorealistic translucency in a questioning way. For this we need alternative ways of encountering simulated lighting effects, apart from blindly incorporating the perspective of the computer model. It takes more radical approaches to the process of approximation to shake our faith in the 'recovery' process of appearance models.[11]

For the moment experimentation with light rendering programs has been limited to extending their applications and aesthetic possibilities. Appearance models can offer an alternative perspective to naturalistic depiction. Architectural design is increasingly applying digital lighting programs to choreograph spaces that address human perception and multi-sensory experience, more in line with the aesthetics of Supermodernism. Here experimentation with computer-generated visual effects aims to evoke a sensuously rather than optically defined spatiality.

Within the computer graphics industry, refinements in light rendering techniques serve an essential role in overcoming undesirable uncanny effects in 3D computer animation. However, subsurface light transport models are costly in rendering time and are not suited to computer games and many graphics formats. Recent experimentation with alternative solutions that can be rendered quickly in games environments includes algorithms which translate the scattering effect simulated in a 3D model to screen space in a simplified form (Jiminez et al. 2010), and the

proposal of even more rapid shading models (Gomez 2011). Unlike photon-mapping models of subsurface light transport, shading models provide impressionistic visual cues such as light source direction, colour gradients and blurriness, that help make an object appear translucent. With experimentation to produce ever faster 'real-time translucency' comes a proliferating technical typology of synthetic illumination. Although superior in terms of speed, the look achievable with real-time techniques is still inferior to the results achievable with photon-mapping techniques. Within the typology of synthetic illumination the subsurface light transport models discussed throughout this essay produce images that are formatted with the attributes of 'true translucency'.

Here we have not only a computational model but also a model form of translucency. Ultimately, the unparalleled authenticity of 'true translucency', as recognized in computer graphics parlance, is a revealing expression that encapsulates the unseen substrate of digital image synthesis: an all-in-one translucent controlling medium, with an infinite capacity for absorption and diffusion of other media.

References

Bergson, Henri. (1908) 1988. *Matter and Memory*. Translated by Nancy M. Paul and W. Scott Palmer. New York: Zone Books.

———. 1911. *Creative Evolution*. Translated by Arthur Mitchell. New York: Henry Holt and Company.

Brown, Alecia. 2001. 'Coca Cola looks to market milk.' *ABC Rural News*, 4 January. http://www.abc.net.au/rural/news/stories/s230115.htm.

Darley, Andrew. 2000. *Visual Digital Culture: Surface Play and Spectacle in New Media Genres*. London: Routledge.

Deleuze, Gilles. 1986. *Cinema 1: The Movement-Image*. Translated by Hugh Tomlinson and Barbara Habberjam. Minneapolis: University of Minnesota Press.

Donner, Craig, and Henrik. W. Jensen. 2006. 'A spectral BSSRDF for shading human skin.' *Eurographics Symposium on Rendering*: Cyprus, June: 409–17.

Fer, Briony. 2000. 'Some translucent substance, or the trouble with time.' In *Time and the image*, edited by Carolyn Bailey Gill, 69–78. Manchester: Manchester University Press.

Fleming, Roland W., Henrik W. Jensen, and Heinrich H. Bülthoff. 2004. 'Perceiving translucent materials.' In *Proceedings of the 1st Symposium on Applied Perception in Graphics and Visualization*, APGV 2004, 127–34. Los Angeles, California.

Frisvad, J. R., N. J. Christensen, and H. W. Jensen. 2007. 'Computing the scattering properties of participating media using Lorenz-Mie theory.' In *ACM SIGGRAPH 2007*, Article 60, 1–10. New York: Association for Computing Machinery.

Gomez, Christian Gascons. 2011. 'Fast Simulation of Translucent Objects.' Master in Computing diss., Polytechnic University of Catalonia.

Harbisou, Robert. 1997. 'Models.' In *Thirteen Ways: Theoretical Investigations in Architecture*, 84–98. Cambridge, Mass.: MIT Press.

Ibelings, Hans. 1998. *Supermodernism: Architecture in the Age of Globalization*. Rotterdam: NAi Publishers.

Jensen, Henrik Wann. 2001. *Realistic Image Synthesis Using Photon Mapping*. Wellesley, Mass.: AK Peters.

———. 2005. 'Cornell box images.' Last modified 30 November, 2005. http://graphics.ucsd.edu/~henrik/images/cbox.html.

———. 2006. 'Subsurface scattering.' Last modified 16 April, 2005. http://graphics.ucsd.edu/~henrik/images/subsurf.html.

Jensen, Henrik Wann, and Juan Buhler. 2002. 'A rapid hierarchical rendering technique for translucent materials.' *ACM Transactions on Graphics, SIGGRAPH 2002*, San Antonio, 21 July (3): 576–81.

Jensen, Henrik Wann, S. R. Marschner, M. Levoy, and P. Hanrahan. 2001. 'A practical model for subsurface light transport.' *Computer Graphics: Proceedings of SIGGRAPH 2001*, 511–18. New York: Association for Computing Machinery.

Jiminez, Jorge, David Whelan, Veronica Sundstedt, and Diego Gutierrez. 2010. 'Real-Time Realistic Skin Translucency.' *IEEE Computer Graphics and Applications*, July/August: 32–41.

Kaltenbach, Frank, ed. 2004. *Translucent Materials: Glass, Plastic, Metals*. Basel: Birkhäuser Publishers for Architecture.

Manovich, Lev. 2007. 'Information as an aesthetic event.' Lecture given at the Tate Gallery, London, 8 September. http://manovich.net/index.php/projects/information-as-an-aesthetic-event

Merleau-Ponty, Maurice. 1962. *The Phenomenology of Perception*. Translated by Colin Smith. London: Routledge; Kegan Paul.

Mori, Masahiro. 1982. *The Buddha in the Robot*. Tokyo: Charles E: Tuttle Co.

Rowe, Colin. (1955–56) 1976. 'Transparency: literal and phenomenal (with Robert Slutzky).' In *The Mathematics of the Ideal Villa and Other Essays*, 160–83. Cambridge, Mass.: The MIT Press.

Sontag, Susan. 1966. 'Against interpretation.' In *Against Interpretation and Other Essays*, 4–14. New York: Farrar, Strauss & Giroux.

Stevenson, Seth. 2002. 'Things go better with ... a shelf-stable kids' lactic drink.' *Sydney Morning Herald*, 18 May, 43–47.

Vasseleu, Cathryn. 2003. 'What is virtual light?' *Culture Machine* 5. http://www.culturemachine.net/index.php/cm/article/view/254/237.

———. 2012. 'Material-Character Animation: Experiments in Life-like Translucency.' In *Carnal Knowledge: Towards a New Materialism Through the Arts*, edited by Estelle Barrett and Barbara Bolt, 153–69. London: I.B. Tauris.

Vidler, Anthony. 1992. 'Transparency.' In *The Architectual Uncanny: Essays in the Modern Unhomely*, 217–25. Cambridge, Mass.: The MIT Press.

———. 2003. 'Transparency: literal and phenomenal.' *Journal of Architectural Education* 56 (4): 6–7.

Von Simson, Otto G. 1962. *The Gothic Cathedral: Origins of Gothic Architecture and the Mediaeval Concept of Order*. 2nd ed. New Haven: Princeton University Press.

Weschler, Lawrence. 2002. 'The race to build a perfect face.' *Wired*, 6: 120–27.

Notes

1. A portion of this essay has appeared in 'Material-Character Animation: Experiments in Life-like Translucency,' published in *Carnal Knowledge: Towards a New Materialism Through the Arts*, edited by Estelle Barrett and Barbara Bolt (Vasseleu 2012). I originally wrote the extract material as a sequel to an earlier essay, 'What is Virtual Light?', which considered the development of the computer as a light-source (and light rendering programs specifically) in terms of a broader, cultural refiguration of light's ontological status (Vasseleu 2003). The sequel essay went unpublished until an opportunity arose to expand on the material process of computer-rendered translucency in the longer essay published in *Carnal Knowledge*. I thank Barbara Bolt and Estelle Barrett for agreeing to the repnblication of the extract in this volume dedicated to critical accounts of contemporary digital light-based technologies.
2. The 'myth' of transparency and its revival as a new principle of 'good modernism', exemplified by making a monument disappear in relation to its context (as in the Louvre Pyramid), as well as and other aspects of architectural transparency are discussed by at length by Anthony Vidler (Vidler 1992: 217–25).
3. Robert Slutzky's influence as a painter on the idea of phenomenal transparency in architecture is also discussed by Vidler (Vidler 2003: 6–7). Rowe and Slutzky acknowledge Gyorgy Kepes' initial description of phenomenal transparency, which they elaborated in their essay.
4. A shutter closing, functions as a thickening or blind spot that can be seen though. The closed off inner core of translucent substances functions likewise. Realised in both form and substance, the eclipse is a temporary death or moment of detachment of the subject, partially suspended from the field of vision (Fer 2000: 77–78).

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