









# **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 textual 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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much as historians of America skip over Leif Erickson's arrival in North America about 1000 AD in favour of Columbus in 1492. There is no continuous intellectual thread that descends from the earlier events. In 1936 the notion of universal computation, effective procedure, or recursive function, etc. was derived by the likes of Church, Turing, Post, Kleene and others. Beginning particularly with 'Saint' Turing, there has been an explosive growth of the notion of computability into actual machines that realize the

universal computation controlled by software to designate which of the infinity of computations is to be universally simulated. Digital light is a subset of this world, and appeared early in the history of computation (at least as early as 1947 that I have been able to ascertain). The background to this discussion is explosive, exponential growth.

The fact that the growth from 1936 has been not just firm and steady, but explosive and revolutionary, is captured by Moore's so-called Law. By reworking the math just a little, one gets a useful and intuitive statement of Moore's Law: *Anything good about computation gets better by an order of magnitude every five years*. Or '10x in 5'. So, taking 1965 as about the time when computers began being realized with integrated circuits (to which Moore is restricted), we have been riding Moore's Law for 45 years. 45 years divides by 5 years into 9 units—9 cranks of the Moore's Law handle—so Moore's Law predicts a  $10^9$  improvement in computers between 1965 and 2010. That's an improvement by a factor of a billion (1,000 millions, see fig. 1). So a kilobyte of memory in 1965 would be  $10^3 \times 10^9 = 10^{12}$  bytes today, or 1 petabyte. Pixar measures its memory in petabytes today. I tracked the development of computations devoted to computer graphics for many years and it did follow Moore's Law almost exactly. I'll give examples later. Ed Catmull and I used the 'Law' for years to make business decisions—it was that regular. Importantly for our discussion here, the digital revolution has been revolutionary—and is still fully underway. This is the force field underlying everything about which I speak.

I like to say: *The computer is the most malleable tool ever invented*. It is our goal—and my constant challenge to artists, the explorers at the edges of our culture—to understand what the medium of computation really is, as opposed to what

#### An Order of Magnitude Every Five Years (10x in 5)

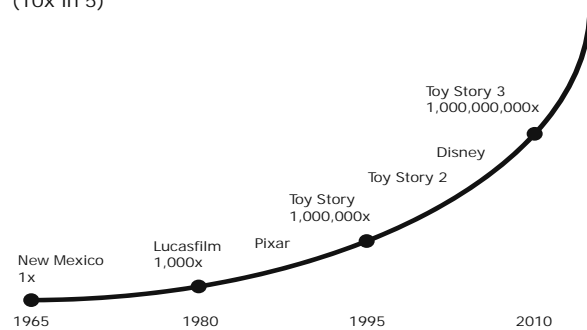


Figure 1. Moore's Law in meaningful form.  
Courtesy of Alvy Ray Smith.



accurately IF the reconstruction is done correctly, and the Sampling Theorem tells how this is done. In other words, IF ONE IS CAREFUL, a discrete set of point samples is equivalent to a continuous infinity of points. Otherwise none of our digital displays would work. We think we are looking at a continuum when we watch digital light. To a large degree the history of computer graphics is the learning of how to cross back and forth across the discrete/continuous border defined by the Sampling Theorem. It is so fundamentally important that I think it should be taught in every school to every child. It defines the modern world.

The computer animation of Pixar is geometry-based. The sets and characters are defined with geometrical elements, assumed to move continuously through time. But consider digital photography. There is no geometry at all involved. The 'real world' is sampled with an array of sensors on a rectilinear grid.

The two worlds have different terminologies and different software applications. An early pair of apps makes the point: Apple's MacDraw was geometry-based; its MacPaint was sampling-based. Today Adobe has Illustrator for 2D geometry and Photoshop for 2D sampling. The interfaces of the two worlds are completely different. You can't know how to operate Photoshop by learning how to operate Illustrator. (I think this is a 'locked-in' error, by the way, and is not necessary.)

In the early days the two branches held side-by-side conferences. As a new assistant professor at NYU straight out of graduate school, my first chairman was Herb Freeman. He had established the first learned journal in the field, called *Journal of Computer Graphics and Image Processing*.

The history of 'computer graphics' often fails to acknowledge the simultaneous development of the sampling side. For example, I've often heard that Ivan Sutherland was the father of computer graphics, but I can't see how that could be true. He came along a decade or more after the earliest computer picturings that I know of—on a Williams tube (32 x 32 memory array of dots on a CRT type tube)—which is sampled, not geometric, and appeared in the late 1940s and early 1950s. Ivan did important early work in the 1960s in interactive geometry-based digital light, but there was

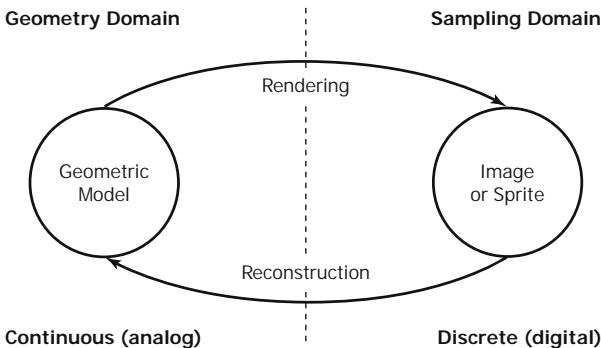


Figure 2. Geometry vs. sampling. Courtesy of Alvy Ray Smith.























































































\* ( HYffm: UI hcb

the standard eventually became 1920 x 1080 pixels (which had a relationship to the analogue NTSC format).

Standard HD is known as having 2k resolution because it has a resolution of 1920 x 1080 pixels (1920 is near 2000). This has a 16:9 or 1.77:1 aspect ratio, which is common to LCD, LED and plasma television design. Cinema style HD has been called Electronic Cinematography—it is also 2k but has 2048 x 1080 pixels (or sometimes 2048 x 1080 pixels, which is 4:3 aspect ratio. So there are varying requirements concerning the number of pixels in an electronic cinematographic image—agreements still have to be made as to exactly what numbers are involved though this is getting closer with the Academy Colour Encoding System (although this is primarily a system to determine standardised colour through different media, it will have a knock on effect with regard to resolution). There is also one other important difference between Standard or HD resolutions (which are governed by proprietary formats) and Electronic Cinematography. Proprietary forms of HD are generally processed (or data reduced and processed) in camera, whilst Electronic Cinematographic forms are processed mainly in the post-production house. 4k is 4096 x 2160 pixels (2:1) or 4096 x 2304 (16:9), and 8k is 7680 x 4320 (16:9)—this last is NHK's Super Hi-Vision. In conversations with leading designers in the subject area I have established that far higher resolutions than 8k are in development.

It is possible to record most of these formats in a compressed version on a form of memory card, but currently, the highest level of 2k HD image capture requires recording onto solid state discs—and not just any solid disc, but a Redundant Array of Independent Discs—a RAID (the exception is Sony's SR deck, which records data on tape). If you want to record 1920 x 1080 pixels uncompressed, then you need read and write speeds of over 440 Megabytes (Mb) per second. The average old style hard drive reads and writes at around 35 Mb —hence you need quite a few of these (though solid state drives record much higher rates you still need several of these too). To understand the idea of the RAID, imagine the following: If I throw you a ball, you might be able to catch it. If I manage to throw you twenty balls at the same time, you have no chance. If I throw twenty balls to you and another nineteen friends—you have a chance of catching them. A RAID Array uses a group of discs to catch large amounts of data.





technologies requires a basic understanding of 'compression' (and this is without a deeper discussion of ever increasing colour bit depth where veracity of colour and a larger data collection is required to pursue the twentieth century's primary aesthetic project, that of realist and hyper realist intent). This question should be: How do we accomplish so much with so little?

Light is focused through a lens onto a charged coupled device or sensor, which then emits electrical impulses that are reconstructed as data. Very early on in video production, a question arose for designers when far more data was generated through this process than was recordable. It was from this problem that the idea of throwing 'unnecessary' data away took hold. A strategy that commercial producers utilize is that of adopting the idea of GoP structures to compress images—and this practice underpins not only low-level HD recording in camera, but transmission of images over the Internet.

GoP is short for Group of Pictures. The first and last frame in a group of pictures contain all the information: each succeeding picture only contains the changes in the information. If a person is photographed against a background, there is no need to resend the background information again and again—only the information about head, mouth and eye movements. You can see the affects of GoP structure effects when you watch the blocky artefacts in DVD or Blu-ray, or HD transmission occurring—there is a regular beating in the change of the blocks. HDV, P2 and AVC cameras use this system to record images and it is often criticized for being unable to handle motion well. Clearly the shorter the GoP structure, the better this system will handle motion.

The traditional photographic camera manufacturing companies have recently got on the bandwagon, taking advantage of the convergence of still and motion picture imaging. Some DSLRs, but not all, had the benefit of a 35 sized single sensor—but with limited writing speeds were restricted to GoP structure compression. By the end of 2011 Canon brought out the Canon C300 to fully enter the motion imaging market place. However, in an act that could be seen as an attempted spoiler, Red introduced the Scarlet X on the same day at half the price and like its antecedent, the Red One, with full frame recording. Some fans of Red complained that the Scarlet was simply a diminished version of Red's Epic camera, one that did not value the rapid developments in the area. Others appreciated the gesture of the possibility of the mass availability of the technology.

Other motion image manufacturers lead by Red, Arri, Panavision and now joined by Sony and Panasonic, realize—mostly through pressure by the cinematographic community—that one of the baseline rules necessary to achieve True Digital













days, if you didn't get exposure correct, then you didn't get focus. Colour itself was grafted onto an already set formulation of image capture. I shot one of the first features generated on video and transferred to film for theatrical distribution; this was Birmingham Film and Video Workshop's production *Out of Order* (Jonnie Turpie, Birmingham Film and Video Workshop/Channel 4/BFI, 1987), and I approached the task by imagining video as being like a reversal stock—with very little latitude for mistakes in exposure. Nevertheless, what had I to lose? I tried various colour experiments—for instance, at that time creating a white balance that was off-white was not generally done. I discovered that not only could you tip the white balance towards the corrective areas of colour (blue and orange, cold and warm), you could also tip the balance of colour into any complimentary area—for instance, corrupting the look towards the purple to induce green and any variation to be found around the colour wheel. The transfer to film at that time seemed adequate, but when compared to today's digital transfer techniques, it was not good in terms of colour.

With the advent of Digital Cinematography something very important has happened with image capture. In both photochemical and digital cinematography, until the image is developed, the image resides in latent form in both *the silver halides* and the *un-rendered data*. Development—the bringing forth of an image in film—is similar to the rendering of an image in the electronic domain except for the fact that the materialised film image is negative and in digital cinematography the materialised image is positive. The nature of that difference requires fuller investigation at another time.

For now, it is important to note that, in the latter, colour is within the bit-depth of electronic data and is therefore an integral part of its material form. This developing practical understanding in professional practice is counter to arguments that have circulated previously within media theory. For instance, *New Media: A Critical Introduction* (Lister et al. 2003: 13–21; 35–44) claims there is an essential virtuality to new media, with the immateriality of digital media stressed over and over again. However, industrial and professional expertise now challenges academic convention by seeking to re-inscribe digital image making as a material process. Data labs exist and so one can deduce that data also exists. Large companies like Google and Microsoft position server farms within the arctic circle to take advantage of free cooling – the manipulation of data generates heat. There are various other characteristics to the handling of data that enhance its materiality and evidence is mounting of its materiality as a medium. In a conversation with a colourist in London's Soho, I proposed that the analogy of 'warming the photo-chemical developer, to then change the characteristic response of the film that was going through the developing

















and Development, on extending my earlier investigation into the immersive qualities of the image through increases of resolution, by combining the properties of higher frame rate, higher resolution and higher dynamic range images. In November 2012 we completed the first ever test shoot for this level of motion image production at 50 and 200 frames per second—the latest capture project took place in Bristol in April 2013, the results of which were published in a BBC White Paper at IBC in September 2013 entitled ‘The Production of High Dynamic Range Video’, by Marc Price, David Bull, Terry Flaxton, Stephen Hinde, Richard Salmon, Alia Sheikh, Graham Thomas and Aaron Zhang.

If you look at figure 1 it shows that the human eye/brain pathway uses 5 out of a 14 order of magnitude scale, sliding this instantaneous facility up and down the scale to deal with starlight at one end and desert sun at the other. All contemporary displays only currently show between 2–3 orders of this scale, but we now have a new prototype which displays across 5 orders and the BBC in turn have created a 200 frame per second projection system. By combining variants of frame rate, resolution and dynamic range, we should be able to effectively produce ‘the perfect picture’ by then calibrating these functions to produce a combination that best resonates with our eye/brain pathway—and therefore conscious awareness. The proposition is that if we can manipulate *all* the factors of the construction of the digital image then conscious immersion may follow.

## Human Overall Luminance Vision Range (14 orders of magnitude)

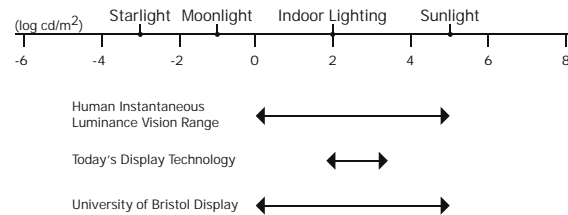


Figure 1. Human Overall Luminance Vision Range.

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them around (Cramer 1989; Tunncliffe and Ewington 2009). As happens when you whirl lights around, they form continuous circles in your visual space because the retention of the image in your retina holds the stimulation and makes a complete circle from it. Then he would let the lead go: Bang! And the lamp would shatter as it hit the floor. A touch dangerous, and you wouldn't want to have been too close when the lamp hit the floor. Fortunately the floor was concrete and not electrically conductive, so that was not an issue.

All the above examples are of analogue light, and it is the means of their control that distinguishes them from the digital. So let's now look into the digital. The notion of the digital comes from the idea that we can treat objects as being discrete and therefore countable and, since it was with our fingers (our digits) that we began to count them, we have been led to recognise that objects might be represented *digitally*. This notion of the discreteness of things is counterposed to the idea that much of what we actually look at and in other sensory modes hear or feel, exhibits an apparently continuous change in, say, strength (amplitude) or tone (frequency) and can thus be represented by some analogical value in an appropriate measuring scale. The difference between the digital and the analogue is not unlike the difference between the integers and the real numbers. So supposing that this notion of discrete objects—and that we can count them with discrete whole numbers—is what we mean, then it seems to me that the question: 'What is digital light?' can be answered via the act of switching something—in this case light—on and off.

In electrical terms, what digital means is simply switching between two states, one is on (connected), zero is off (disconnected). That's all it means. It comes right back to the telegraph when it was originally developed—by one Charles Morrison of Renfrew, Scotland in 1753 (Mottelay 1922: 208). To send a signal what one did was to take a Leyden Jar, which was your battery, and two pieces of wire. You stuck one end of one of the wires onto the battery and its other end to something that would tell you that a current was flowing (often a small explosive charge), so you were literally just holding the wire onto, or removing it from the battery. The second piece of wire was simply to provide the return to the negative side of the battery. But importantly what

Morse Code Switch

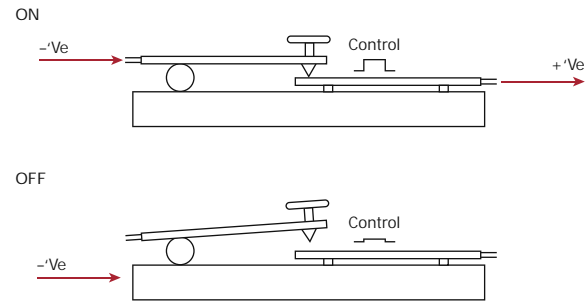


Figure 1. Morse code switch. Digital signals are switched between two states: ON and OFF. This can be done manually by using one's 'digit' or finger to make a connection. The result of the change of state is that current flows along the wire.

## Switch

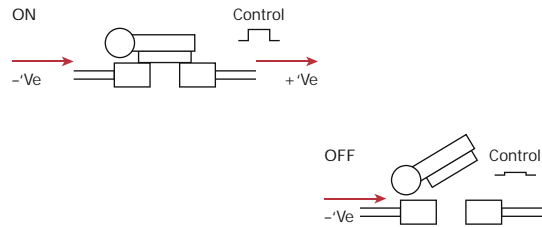


Figure 2. Manual switch. Digital signals are switched between two states: ON and OFF. This can be done manually by using one's 'digit' or finger to flick a switch. The result of the change of state is that current flows to the lamp.

## Triode Valve

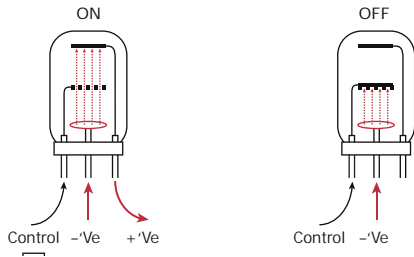


Figure 3. Electron Tube: Digital signals are switched between two states: ON and OFF. This can be done electronically by using a control current to permit the electron flow from the cathode (-'ve) to the anode (+'ve).

## Transistor

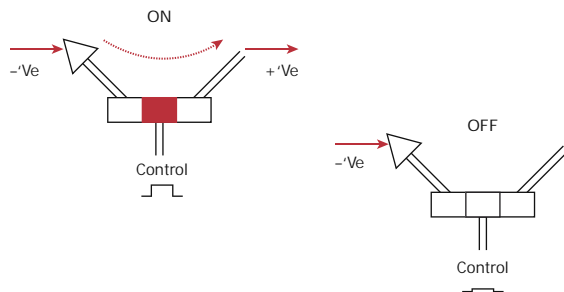


Figure 4. Transistor: Digital signals are switched between two states: ON and OFF. This can be done electronically by using a control current to permit the electron flow from the cathode (-'ve) to the anode (+'ve).

is happening is that the wire is carrying pulses of electricity. Over the next eighty years, this action became more sophisticated and evolved into the Morse Key, which does exactly the same thing only now you're pressing the button with your finger, and of course there is that very useful notion of the relation of the digit (as finger) and the number (see fig. 1).

So the telegraph is the first digital process, the first switching of signals on or off. Then, once the electricity supply was strung up through our cities, you have the standard light switch and when you switch the light on at the wall you are performing a digital act (see fig. 2). Now, of course, you can take away the finger and use a piece of electronics to do it. In the early days, with the computers I am about to discuss, you did that with valves. A switching valve is a three electrode device or triode, with a source of electrons (the cathode), a control electrode, which can be switched on or off by an externally supplied voltage, and an electrode that receives the electrons and sends them on their way (see fig. 3). Here one now has electronic switching and this is where binary digital starts in terms of computing. The next stage of this is with transistors, which are essentially exactly the same as triode valves, only much smaller, and we can also control them electronically (see fig. 4). So these become the basis for any kind of digital circuitry.





eight lamp-drivers switched by the state of the flip-flops and the necessary control circuits to set up patterned and random sequences to control the lamps. On its face are the lamps, each with a diffusion screen to even out the filament's bright spot. It could produce all kinds of rippling sequences, shifting blocks, back and forth movements and other patterns. It also offered a degree of interaction in that, by the use of its control panel, one could program it to produce all kinds of controlled kinetic displays (Smith 1972: 59–61; Malina 1974: 157–59). It was probably the first digital electronic artwork made in Australia.

So now I am going to discuss CRTs.

The first image produced by an avowedly *digital* electronic device is the image that Tom Kilburn made for his report on the Williams–Kilburn tube, an electrostatic storage device or memory developed at the University of Manchester between 1947–48 (Kilburn 1947) (see fig. 5).<sup>4</sup> It used what are described as ‘secondary electrons’, or electrons produced by stimulation of the phosphor inside the face of an oscilloscope. While the phosphor primarily produces photons the physical action of the electrons striking the phosphor also produces these secondary electrons, which leak out through the glass face of the tube and can be detected by a metal plate placed in close proximity to the glass of that face. If one taps off the charge that momentarily energises this metal plate and re-circulates it back into the oscilloscope, then timing circuits produced by a computer driving this electrostatic-storage tube can tell the computer the state of a particular location on the tube face while refreshing that state so that it acts as a memory (Williams and Kilburn 1949). Effectively the Williams–Kilburn tube is a form of dynamic RAM but more importantly for us it carries a map of the contents of the computer’s memory and if the waveforms utilised by the storage tube are tapped off and used to drive another oscilloscope then we can actually see the contents of memory as a raster or grid (Jones 2011). This is the first bit-map, although its origins can be seen in the Jacquard loom and even before that in the Turkish carpet. But this is the first electronic version and, I argue, it produced the first digital light.<sup>5</sup>

### Williams-Kilburn Electrostatic Storage Tube

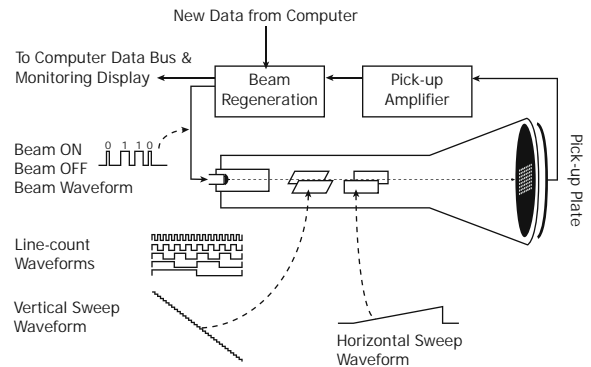


Figure 5. Williams-Kilburn tube Electrostatic Storage Memory. The Line-count and the Vertical Sweep waveforms control the position of the beam spot which is turned on or off by data from the computer. This places a grid of light spots on the screen which last for long enough to be re-generated; and if the Pick-up plate is removed an image can be displayed.

Now, memory is something that is primarily used in computers, and computers are the primary way in which we control the construction and display of digital images (or digital light). The first computer to be built in Australia was the CSIR Mk I, at the CSIRO division of Radiophysics (c.1947–51) on the University of Sydney campus. It was moved to Melbourne in 1956 where it became CSIRAC. The logical design was done by Trevor Pearcey and the hardware design was done by Maston Beard (McCann and Thorne 2000; Deane 1997). It used a different kind of memory known as an acoustic delay-line, but it did use CRTs to display the contents of that memory at the grand resolution of 20 pixels by 16 lines, and it was pretty obvious that if you stored bits at the right locations you could produce a crude image. Given that, the first 'real' (i.e., not done for entertainment purposes) computer graphic produced in Australia was a display of the output of a

Figure 6. The 'peeing man'. Frame from an animation made by storing the appropriate numbers in the appropriate locations on the face plate of a Williams-Kilburn Tube.

numerical weather forecasting program written by Ditmar Jenssen for his MSc thesis in meteorology (in 1957). The images are weather maps, the upper one showing the current day's isobars and the lower the isobars for the next day.

The second computer built in Australia was SILLIAC. It was built for the School of Physics at the University of Sydney and was used to do some important work in the physics of the nucleus and in astronomy. It was completed in 1956 and was operated until 1968. It used 40 Williams-Kilburn tubes for memory (giving it 1024 40-bit words), and the operator could tap any word of memory and display it on a monitoring CRT with a resolution of 32 pixels by 32 lines. By filling its memory with the right numbers it could be made to display text. Around 1964 it was replaced by an English Electric KDF-9 and SILLIAC was handed over to the senior computing students who used it for their projects and for entertainment. Of the latter one of the things they

did was an animation—done by filling, on a cyclical basis, the appropriate locations in memory with the right numbers. It starts as an outline of a man who lifts his arm and fills himself up with beer, he then puts his arm down and pisses it out (Jones 2011; see fig. 6). It is the only animation that anyone can remember from the time although there were probably more, but its outrageousness did make it memorable.

So the first digital light produced in Australia came from these two machines. Having established that one could produce images, the next problem was to get a greater resolution and for that, at this period in the history of computing, one had to use a vector (or calligraphic) display. These were CRT displays that functioned more like an oscilloscope and were adapted from the Radar display. They drew by magnetically deflecting the electron beam issuing from the cathode directly around the interior of the tube as it stimulated the phosphor on the inside of the face-plate to give off photons. Thus the vector display inscribed an image in lines onto the face of the CRT (see fig. 7).<sup>6</sup>

Around 1967 the Basser Computing Department of the School of Physics at the University of Sydney, which housed SILLIAC, acquired three other machines, among them being a DEC PDP-8 and its attendant 338 Display, which was a 1024 by 1024 point vector display. It could produce straight and curved lines—which were assembled from short straight lines—at high resolution and in quick succession so that it could build up 3D images and animations more or less in real-time. It took very little computing power to transfer to the display computer (and then onto the screen) the data about where each line or object (an assembly of connected lines) should be. Its limit was that it could only draw lines (vectors) and you couldn't draw shaded areas. But you could produce animated drawings and record them to film.

The PDP-8 and its display were used for projects ranging from scientific visualisation for the Aeronautical Engineering Department at the University of Sydney to animations and still graphics for artists and filmmakers. There was even an attempt to produce TV station IDs with it. The scientific visualisation (produced over 1967–68) was an animation (recorded to 16mm film) of the movement of air molecules at the very low densities encountered at the edge of space and was calculated to show the movement of the molecules as they impacted on each other and the leading

### Vector Display

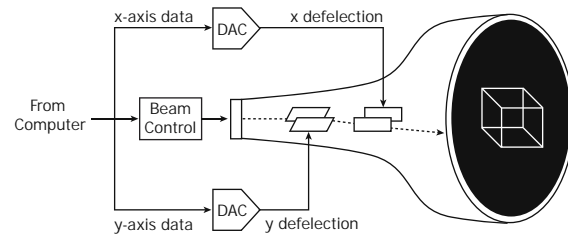


Figure 7. Vector or Calligraphic Display. The beam is pushed directly around the screen according to voltages imposed on the deflection coils by a computer. The images are, thus, line drawings.







Figure 8. Images from the video screens at Australia 75: Computers and Electronics in the Arts. The image is produced by a computer reading and displaying the positions of four dancers on a set of pressure sensitive floors.

Australian National University (ANU) Research School of Physical Sciences, Harvey Dillon, Steven Dunstan and musicians from the Melbourne-based New Music Centre, John Hansen, Ariel and Joseph El Khouri from Bush Video, and Stan Ostojak-Kotkowski.

Due to the breakdown of a computer-controlled patching system built for Cullen by Connor and Schiemer, it became necessary to attach her pressure sensitive floors—another interactive device she had had built—to a DEC PDP-11 and an associated digital frame-buffer that could hold an image of 512 x 512 pixels

by 4-bits per pixel (thus R, G, B and Intensity). The frame-buffer had originally been built by the ANU team to assist its work in Landsat image interpretation but was brought along to the exhibition to show off a paint package and drawing tablet that they had also developed (Ellyard and Macleod 1975). The situation led to the PDP-11 being enlisted to read the signals from the floors through its Analogue to Digital Converter (ADC), and to generate an image in the frame-buffer of the recent history of the dancers' movements on the floors. The RGB signals from the frame-buffer were then sent to John Hansen's video synthesiser and mixed with live camera images of the performance, and the whole spontaneous collaboration is an early example of interactive video and the use of digital images to generate video light (see fig. 8).

After the Canberra show, Hansen returned to Melbourne and continued to work in image synthesis, building a second video synthesiser that used one of the newly available Intel 8080 microprocessor chips to control the ADC and the signal patching. The project then evolved into a computer graphics system based on the vector techniques of computer-aided design applications. Over the next few years he and his colleague, Chris Ellyard, whom he had met in Canberra, assembled a 2D drawing and paint program called Conjure. It originally ran on a Z80-based Matrox graphics card system and then in 1982 was ported to an IBM PC-XT. The images were stored as lists of vectors in the computer so that they were scale independent and the results could be rasterised for video display. With this approach the displayed graphic was a bit-map but the source was still vectors and shading was not easy

(see fig. 9). However, as with 3D graphics the vectors are where you do the work and then you project the results onto the 2D plane, and the rasteriser performed that projection. Conjure's main output formats thus became video and corporate A-V slide production (Hansen 1998), and while Hansen's work is fairly early we all know what can happen given all the developments that have taken place since then. One small example is the use of Conjure in music videos that were made through Heuristic Video, an independent and experimental post-production facility in Sydney.

Figure 9. Image produced on the Conjure system for raster display. Calculations could be scaled to either a video raster display card or to a film recorder for slide production. Courtesy of Martha McKelvey.

I want to briefly mention two other developments. One is the appearance of the Silicon Graphics IRIS system and the purchase of two of them by the Video Paint Brush Company (VPB) in Melbourne in 1983–84. They used animation software from Wavefront which, interestingly enough, given our topic 'was named after the term which describes the front edge of a wave of light' (Carlson n.d.) on the IRIS machines. The IRIS machines were rapidly followed by the Quantel Paintbox. Both systems were used to produce TV commercials and some computer art. Some of the operators were Jean-Marc le Pechoux (who established the company), Sally Pryor, Andrew Quinn and Jon McCormack, all of whom had trained at the Swinburne Institute of Technology and Felicity Coonan who worked at the Sydney branch. Artists who used the systems at VPB included Jill Scott.

The other development is Tom Ellard's work with the Amiga 1000. His band Severed Heads was established in 1979 and he worked with some of the very early domestic computers including the Commodore 64. Around 1983 he teamed up with the author to produce video clips for the band and in 1986 began to use the Commodore Amiga 1000 in that project (Ellard 1998). The Amiga was an especially important domestic level computer because of its innovative architecture. Commodore developed two special purpose integrated circuits and the bus architecture placed the image memory in the same address structure as the microprocessor's memory. With the aid of the *Agnes* address generator chip, the *Denise* graphics chip had direct access to the image memory and this meant that getting a reasonable resolution graphic animation out of the machine could be done in real-time, making

Figure 10. Image produced on the Amiga 1000 and the Conjure at Heuristic Video. Courtesy of Tom Ellard.

it excellent for use in video animation and titling, and making clips at Heuristic Video for Severed Heads (sometimes in conjunction with their Conjure system). The software that Ellard initially used was D-Paint II and this gave him the facility to create some quite complex 2D modelling with the capacity to translate and rotate images around the screen (see fig. 10). Together we produced a considerable number of video clips using all sorts of devices ranging from the second of my video synthesisers to a Richmond Hill vision mixing desk with upstream re-entry, the Conjure system and of course the Amiga 1000 which was later

replaced by an Amiga 2000. It wasn't important in the Severed Heads work what kind of machine, analogue or digital, produced the visuals just that they worked with the ideas and melodic structure of the music that Ellard recorded.

So finally, in answer to my opening question: What is Digital Light? I argue that it is simply image-producing light that is organised by and controlled through the use of digital electronics, particularly computers. The key idea is the digital switch and its potential to function as a storage device in which a signal controls the switching on of a light source.

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In contrast, Schwartz' work, like others at the time, was focused on the future. The new art spoke to unknown alliances between humans and electronic machines. Many could not yet understand how or what this new breed of computer artists were up to, yet they at least recognized that there was something powerful and visionary in their work. One other such person was Bell Labs' engineer, Leon Harmon.

## The Machine at the End of the Mechanical Age

Leon Harmon met Lillian Schwartz at the opening of Pontus Hultén's 1968 landmark exhibition, *The Machine as Seen at the End of the Mechanical Age*, an exhibition supported in part by Experiments in Art and Technology (E.A.T.) and held at the New York Museum of Modern Art from 25 November, 1968 through 9 February, 1969 (Schwartz *LIL*: Chapter V, 1; see fig. 1).

On display at the opening night of the MoMA exhibition was Leon Harmon and Kenneth C. Knowlton's important entry: *Studies in Perception No. 1* (1966), dubbed the 'Nude': a 5 by 12-foot computer-generated nude made in one of the first computer graphic languages made for raster film, BEFLIX (an acronym for Bell Flicks) (see fig. 2). BEFLIX was the first specialized computer animation language written to produce mosaic composition languages, or simply, a computer language that could be used for pixel animation and bitmap sequences (Youngblood 1970: 246). Knowlton wrote BEFLIX in 1963 using a high-level set of macro-instructions or MACRO-FAP, FAP was the machine language native to the IBM 7094 machine that they were using at the time and MACRO-FAP indicated an additional ability to, as Knowlton puts it, 'accept a definition of a common sequence of operations, for example, you could write min(a,b,c) to establish the value of the smallest of three numbers instead of

Figure 1. Metal catalogue cover from Pontus Hultén's 1968 landmark exhibition, *The Machine as Seen at the End of the Mechanical Age*. The exhibition was in part supported by Experiments in Art and Technology (E.A.T.) and held at New York's The Museum of Modern Art from 25 November, 1968 through 9 February, 1969.

writing each time the required sequence of half a dozen FAP instructions' (Knowlton 1964; Kane 2008b; Carlson 2003a).<sup>3</sup> BEFLIX was capable of drawing straight lines from dots, drawing curves, copying regions, moving regions, doing a solid fill in specific areas, zooming in specific area, and dissolves and image transitions. After writing the programming language and using it to compose *Studies in Perception No. 1*, Knowlton output the piece in eight sections, using a Stromberg-Carlson 4020 printer. At the time, each minute of output cost approximately \$500 (Reichardt 1971: 77; Kane 2008b; Youngblood 1970: 246).

The final *Studies in Perception No. 1* image consisted of many tiny electronic symbols including multiplication and division signs, transistors, zener diodes, vacuum tubes, resistors, tape reels, and writing crossovers used to compose 11 x 11 arrays. The genius of the piece was the visual effect it created wherein, when viewed close

up, it consisted of thousands of these tiny black and white symbols, but when viewed from a distance, another picture to come into view: a 12-foot female nude. Programming was complex and involved many tedious hours plotting numbers on graph paper, transferring them to punch cards, taking the punch cards down to the processor room, waiting in line, feeding the cards through the processor, and finally, returning the next day or later to see what you got. Often referred to as 'blind programming', one didn't see what

one had until the end of cycle, at which point, one usually saw errors and had to repeat the entire process.

At the MoMA exhibition, Harmon was intrigued by Schwartz's entry, *Proxima Centauri* (1968) (Schwartz *LIL*: Chapter V, 1), engineered by Dutch born Per Biorn. Biorn began working with artists during E.A.T.'s infamous *Nine Evenings* held at the armory in 1966 (Experiments in Art and Technology 1998: 7; Biorn; Schwartz 1969). *Proxima*, unlike the nude, was a mechanical and kinetic light-based sculpture, perched on a 55" x 30" x 30" black plastic base with a white translucent dome on top. The guts consisted of an old singer sewing machine and proximity detector pads so when it was approached by a viewer, four switches turned on a motor that lowered the dome as it changed colour from blue to red. There was also a projector located inside the black box which automatically alternated between eighty-one

Figure 2. Leon Harmon and Kenneth C. Knowlton. 'Nude', or *Studies in Perception #1* (1967), featured in the MoMA's Machine Show. Bell Labs demanded that the artists dissociate the work from the Labs, until it appeared on the front cover of *The New York Times*, when they changed their original directive. Image courtesy of Ken Knowlton.



of Stanley Kubrick's landmark film, *2001: A Space Odyssey* (1968). Despite the movie's futuristic edge, when news of the scene got back to the Labs, 'AT&T was furious' because the public relations department deeply opposed the Labs being associated with commercial media (Kane 2008c; see fig. 3).

Another instance occurred earlier, in 1965, when the Howard Wise Gallery asked Noll and Labs' researcher and scientist Béla Julesz to hang some of their work, some of the first computer generated images ever produced, in their upcoming art exhibition, '*Computer-Generated Pictures*'. Once the Labs caught wind of the event they 'made an effort to halt the exhibit' but it was too late. The Labs thus instructed Noll and Julesz to take out a copyright on the pictures in their own names so the 'art' would not be associated with the Labs. However, the Library of Congress refused to grant the copyright to them 'since a machine had generated the work' and this, the Library of Congress informed them, was 'not acceptable'. Noll explained to the LOC that it was humans who programmed the machine. This explanation failed. In a third attempt he finally received the copyright (Noll 1994: 41). Noll is also quick

Figure 3. A. Michael Noll's picture phone in phone booth, featured in Stanley Kubrick's *2001: A Space Odyssey* (1968), daringly bearing the 1968 Bell Labs logo.

to note that while the piece was not issued a copyright until 1965, it was 'actually made in 1962', making it, not the computer art produced by the Germans, Noll is proud to report, the first work of computer art (Kane 2008c). Computer historian Margit Rosen suggests, however, that there is no known date or 'birth year' for the origins of computer art, as there is with photography and film, 'however fictitious











phenomenon of optical colour mixing. Second, Maxwell's colour experiments are in fact attributed to Goethe who, in his landmark *Theory of Colours* (1810), prioritized subjective colour mixing over Newton's objective colour analysis (see fig. 4). Goethe proposed the 'edge theory' of colour, a thesis that correctly argued that colour is not *in* light, but in fact emerges *in between* black and white, a hypothesis that actually originates with Aristotle, who argued that 'all hue is to be considered as half light, since it is in every case lighter than black and darker than white' (Gowing 1978: 55). In the nineteenth century, Maxwell and his peers, including Hermann von Helmholtz and Gustav Fechner, were inspired by Goethe's work, as were the Op and light artists in the twentieth century. What appealed to them in Goethe's colour theory was the way in which colour was seen and theorized on the *edges* of perception, and thus visual experience became highly subjective. Subjective perception and optical colour theories remained à la mode in avant-garde film and computer art throughout the 1960s and 1970s. However, as I argue elsewhere, by the 1990s and 2000s these subjective techniques fall out of fashion.<sup>7</sup>

The second technique used to generate colour in *Enigma* was accomplished through colour intensification, as discussed above. As colour appeared, more actual colour was added, accentuating the effects of the illusionary colour.<sup>8</sup> In addition to building on research in optics and colour perception, *Enigma*, like *UFOs*, expanded the perceptual field in early computer art. Much of this was possible because colour knowledge was brought into the world of early computer graphics (Schwartz 'Description of Computer Films'). Both of these computer art projects use rapid, stroboscopic computer animations to generate colour in subjective perception. *Enigma* highlights how colour exists in between the (objective) screen and the (subjective)

Figure 4. J. W. von Goethe. Diagram from *Theory of Colours* (1810). Goethe's edge theory demonstrates that colour is not in light (as Newton argued), but in fact emerges from overlaps and through edges.





































































Figure 1. Oscar Rejlander, *The Two Ways of Life*, 1857, combination print from multiple negatives.

work *A Sudden Gust of Wind (after Hokusai)* (1993). A transparency in light box that stands at nearly four metres wide (250 x 397), it is one of Wall's most ambitious and complex 'cinematographic' works, making a direct allusion to art history, remaking a colour woodcut by Japanese artist Katsushika Hokusai in contemporary Vancouver. Perhaps most importantly, *Sudden Gust* is a photograph that juxtaposes movement and stasis. In any of the many texts you might read about this work, one will learn that it was constructed from at least fifty separate images—one hundred, according to some critics—shot from the same single camera position, taken over the course of one year. Indeed, Wall told me himself that the reason it took a year is that he had forgotten to photograph the leaves on the ground, so—in a curious concession to nature—he had to return a year later. Finally, the multiple photographic elements have been assembled in the computer, and digitally montaged, to produce a seamless effect.

There are, of course, countless precedents for the montage process, going back right to the earliest uses of photography. For his elaborate allegorical work *The Two Ways of Life* from 1857, Oscar Rejlander combined at least thirty negatives to produce one of the best-known and most infamous combination prints. The various pieces were carefully joined, and then rephotographed to create the illusion of a single scene. Even in the field of documentary, manipulation has a long history long before Photoshop—as any student of the history of photography knows. For instance, Mia Fineman (2013) tells the story of how, following the end of the American Civil



Figure 2. Patrick Pound, Portrait of the Wind, 2010 (detail). Courtesy of the artist and Stills Gallery.

The Australian artist Patrick Pound has collected an entire series of found photographs that involve the wind, to produce a collage work called *Portrait of the Wind* (2011), featuring women with billowing dresses and men with tousled hair and wayward ties. Of course, the wind is not itself visible in these images, only its effects. Indeed, in Wall's work, given the image is digitally montaged, it is in fact possible that the wind may have never have existed at all, and that we are witnessing effects without a 'natural' cause. Sure enough, the 'sudden gust' was produced by a wind machine, and the hat was tied to a stick with nylon thread. As Wall says:

The montage is composed of acts of photography, even if there is no simple photographed moment. I don't think any photographic qualities are eliminated, except the single moment in which the entire image was made. I admit that may be the decisive absence, but I like to make a picture that derives from that absence and contemplates it. (Quoted in Tumlrir 2001: 116)

Here, the decisive moment has thus become the decisive absence, precisely as photographic space has expanded and multiplied indefinitely. This is now the condition

under which all photographs are potentially produced. I am reminded of this fact whenever I take a photograph with my iPhone using the High Dynamic Range (HDR) setting, which automatically blends together three differently exposed versions of the 'same' scene in an effort to improve details in the shadows and highlights. Since the world does not usually stand still to be photographed, movement in the frame leads to unusual repetitions, ghostings and dismemberments. Even stranger results were generated in the glitchy Apple Maps app in 2012, when cities were peppered with warped buildings and distorted

bridges in the effort to render 3D geometries from 2D images. Galleries of these misfit renders can now be found on the Internet, as an ode to 'algorithmically-authored oddities' (Vanhmert 2013).

Figure 3. An example of 'ghosting' using the iPhone 4S's HDR exposure setting. Photo: Daniel Palmer.

## Camera Conditions: From Apertures to Augmented Reality

Over forty years ago, in a famous work of photo-conceptualism, the British artist John Hilliard laid out what he understood to be the fundamental procedures of photography. The work, *Camera Recording Its Own Condition (7 Apertures, 10 Speeds, 2 Mirrors)* (1971) comprises a gridded display of seventy photographs, arrayed in ten rows of seven across, taken by a camera aimed at a mirror, showing itself at the moment of exposure. As the second part of the title of the work indicates, the snapshot-style images, which move from pure white to pure black, are the result of all the possible combinations of aperture size and shutter speed in Hilliard's camera, an East German made Praktica. In the grid, the artist has positioned the optimal 'correct' exposures in a diagonal line from the top right to bottom left. This changing of the mechanics of each shot reveals the intention of the unseen photographer. Importantly, Hilliard's fingers can be seen operating the camera. Hilliard also holds up a smaller mirror which reflects and makes legible the camera's setting and controls, making it a self-portrait of sorts.

Figure 4. John Hilliard, Camera Recording Its Own Condition (7 Apertures, 10 Speeds, 2 Mirrors), 1971. Courtesy of the artist and the Tate.

Hilliard's work is open to various possible interpretations. It is clearly a commentary on the camera's supposed access to an objective depiction of the real world. By demonstrating the basic operating controls of the camera, focusing on the technical and chemical conditions, and revealing the processes that cause a photograph to appear as it does, Hilliard shows that reality is depicted according to predetermined technical conditions. Notably, the work does not consider focus as one of these 'conditions', nor does it consider film stock or the passage from the negative to the print (we simply assume that Hilliard's photographs are all printed in the same way). As the catalogue entry at the Tate notes, 'Photography is both the medium and the subject of the work, giving not a picture of "reality", but different versions of reality' (Tate). In addition to questioning photographic objectivity, as a work of conceptual art, it is likely, as photographer Jeff Wall has argued, that

Hilliard's work is also a critical commentary on what many artists at the time saw as 'an excessive subjectivism in the then-reigning versions of art photography' (2012: 698). This is the famous deadpan (non-)aesthetic of conceptual photography, particularly that which operated in serial mode, in which the individual creative agency of the photographer is purposely downplayed: here, the camera is simply 'recording', as if it has an agency of its own (Palmer 2013).

Viewing Hilliard's work today, however, with the knowledge of the increasingly sophisticated automation of cameras that was about to occur, starting with basic electronic controls in the 1970s and massively expanded with digital cameras since the 1990s, we can now interpret this piece afresh. Arguably, what the work becomes now, above all, is a homage to the economic simplicity of the camera's 'condition' in the classic age of 35mm *analogue photography*. Today, the activity of taking











themselves from the capture device to a different display screen. Moreover, they have been uploaded to the network and then downloaded again—which in practice can entail some delay, not that you would know this from the Apple commercial, with its reassuring voiceover ‘capture the moment here, and it’s waiting for you there’. The so-called ‘Photo Stream’ is indeed designed to automate the sharing of photographs not only between devices but also between family and friends (using Shared Photo Streams). The seamless nature of the

Figure 5. Apple TV Error Message, 2013. Photo: Daniel Palmer.

process evokes a fantasy of instantaneous distribution and ubiquitous photographic presence. But even Apple’s digital universe is not without its asynchronous moments. Recently, during an attempted viewing, an error message appeared on my display screen which read: ‘Error. Time is over a day old.’ This nonsensical yet strangely poetic phrase, generated without warning or further explanation by the software of my Apple TV unit, raises the question: can time be old? In computerisation, where now is the only time that matters, it certainly appears that time can indeed be too old.

For many of its most important theorists, time is the very essence of photography. Not the now nearly instantaneous time between recording and displaying, but the very possibility of a time-travelling encounter between the past and the present. Thus in his classic formulation of the particular quality of (analogue) photography, Roland Barthes famously wrote:

The photograph is literally an emanation of the referent. From a real body, which was there, proceed radiations which ultimately touch me, who am here; the duration of the transmission is insignificant; the photograph of the missing being, as Sontag says, will touch me like the delayed rays of a star. (1984: 80–81)

This passage is of course an enthusiastic defence of photography’s specific indexical and temporal qualities. Barthes’ use of the word *emanation* is self-consciously Romantic, with its overtones of cosmology and certain religious systems (the word derives from the Latin *emanare* meaning ‘to flow from’ or ‘to pour forth or out of’,

































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.<sup>6</sup> 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 than looking like white paint (Jensen 2006).





## Simulated Human Skin and Its Perceived Translucency

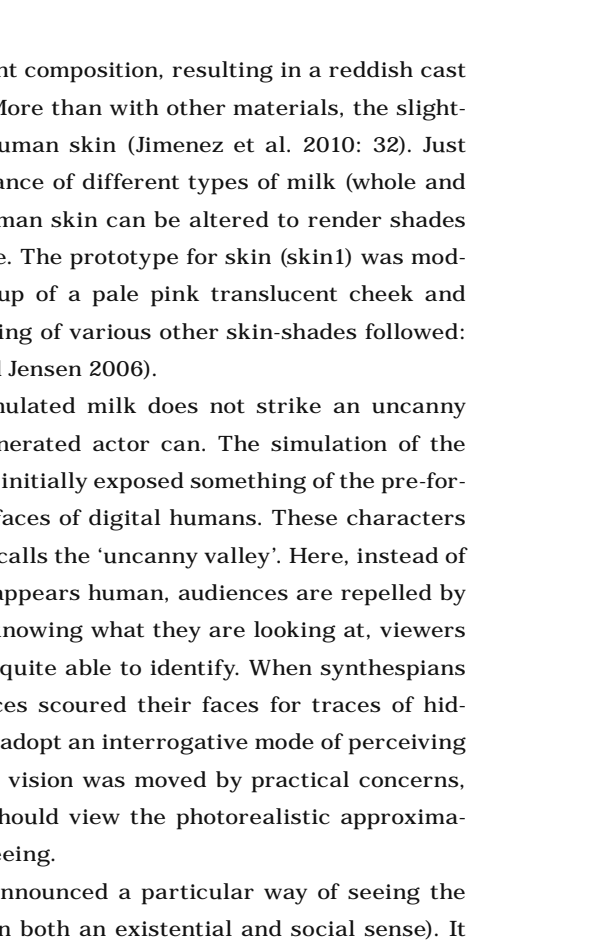
Appearance models describe the procedures for animating the variables that apply to the characteristic appearance of materials and media. Jensen's model for calculating subsurface scattering was quickly adopted by the 3D computer animation industry to photo-realistically render the appearance of human 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.<sup>9</sup> 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.<sup>10</sup> 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

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.



















































media technology's implicit fascination with the unseen, the otherworldly and its manifestation through sound and light.

Contemporary media artists have demonstrated an especially keen interest in the connections between the spectral and the sideshow attraction, particularly as a point of intimate, interactive encounter. Canadian artist Catherine Richards' installation *I was scared to death; I could have died of joy* (2000), for instance, constructs an enclosed world that evocatively blends the curiosity cabinet and the freak show.

Figure 1. Catherine Richards, *I was scared to death; I could have died of joy*, 2000. Photo: Mitch Lenet. Courtesy of the artist.

Two glass canisters resembling nineteenth century specimen jars are set on stainless steel tables in a dimly lit room. The jars, in actuality gas-filled vacuum tubes, contain life-like glass models of a cranium and a spinal cord. As the visitor approaches them the light recedes even further until the room is completely dark. As if sensing this as a kind of bizarre curtain call in a Victorian pathology museum, each object glows in a responsive fluorescence. And it responds to your presence. Katherine Hayles has evocatively described this experience:

When an ionizing current is passed through the gas, the glass models fluoresce, creating a beautifully eerie glow ... [As the ionized gas] arcs towards the visitor's hand, a connection and possibly a communication seems to be established between the interiority of the glass nervous system and the cognition of the visitor as she meditates on the experience. (2000, 10)

The play of light and shadow, brightness and darkness in this work has been described by Hayles as a kind of allegory of our experience of light itself. 'Light', she suggests, 'is the portion of the electromagnetic spectrum visible to humans' (2000: 10).<sup>1</sup> Her response to this foreshortened dimension of vision is to suggest, therefore, that for the most part 'we see darkly'. The act of seeing darkly is an apt figure for thinking about Zika's fascination with the complementary as well as contradictory qualities of digital light.

As attractions that simulate the crossing of thresholds, the unnerving descent into the otherworldly dark rides represent for Zika incipient, premonitory and powerful examples of immersive, virtual worlds. They are potent admixtures of light and shade, uniquely hybrid spaces that combine the mechanics of familiar trolley

Figure 2. Joel Zika, *Arcade # 1*, 2006. Courtesy of the artist.

rides (such as the rollercoaster), the fabricated construction of the walk-through built-environment (haunted house) and the emergent moving image technology of the cinema. Zika points out how such attractions were indelibly associated with the rapid and pervasive urbanism of early twentieth century America: 'As people became increasingly alienated from their local environs, they sought alternative destinations in a variety of forms of escape involving physical as well as imaginary sorts of "transport"' (Zika 2009: 12). Geographically, the locations of these gothic amusement parks were often found in 'a remote, isolated space', in the woods, on the edge of town, or a patch of wasteland (Zika 2009: 13). Symbolically at a distance, as if their horrors could not be countenanced in the streets where people actually lived, this of course added to their titillation as attractions. You had to make a commitment to go to them, a commitment to cross a threshold that assuredly would set the hair tingling on the back of your neck. Zika cannily captures this psycho-geography of expectation in a number of image-based and installation works. For him it represented a key aesthetic and psychological component of the cultural resonance and meaning of such spaces, since the physical journey to get there, which took you to the 'end of the line', was also a 'mythological journey into the unknown' (Zika 2009: 13).

An iconic work in this respect is *Arcade* (2006). A stylized ghoul-like visage glows eerily from an undifferentiated background surrounded by trees. The silhouette of a young girl is seen approaching this unnerving portal, her hand reaching out as if feeling her way through the dark. The chilling second panel of the work reveals the child on the verge of entering into an abstract space (an image also witnessed in *Façade* of the same year). Frozen as a kind of cipher, a filtered image of light, she is forever captured in the intransitive state of *entering*. She is captured as a

Figure 3. Joel Zika, *Arcade #2*, 2006. Courtesy of the artist.

*tableau vivant* beyond recall and, potentially, beyond salvation.<sup>2</sup> Later installation works such as *Inferno* (2007) and *Terrorium* (2009) are uncannily devoid of such an expectant human presence, revealing perhaps reflexively the indifferent and solemn spectacle of a moment that has since passed. All that remains is the glow and enveloping saturation of light.

Central to the spectral, gothic atmospheres of the dark ride was the interplay between light and shade. Indeed, the historian of early cinema Laurent Mannoni describes pre-cinematic projection as a 'deceptive art', the 'great art of light and shadow' (2006: 42). The manifestation of the otherworldly as spectra of light has been traced back many times to the age of the magic lantern. The cone of light channelling through a darkened space bore an uncanny resemblance to steam, the psyche of the machine age. But more alarmingly it is also suggestive of breath, a psychosomatic aspect of projected light that Zika evocatively captures in his work, especially the *At Night* series (2005). Zika's interest in the palette of light and shade is continuous throughout his work in different media from series comprised of still images to immersive installation environments (such as the large scale walkthrough 'amusement' *Terrorium*). I want to focus particularly on *At Night* to concentrate the ways in which Zika mobilizes the seductive malleability of digital light. A latter-day Franz Mesmer, Zika invests the valencies of digital light and shade with the animus of character, of psyche and an enveloping sense of presence. His scenes, in this sense, can be considered less as planar 'inkjet' photomedia images than the orchestrated interactions of an ensemble of *dramatis personae* (mise-en-scène is far too static, less animate a term here). This performative vibe may partly be explained in terms of the artist's actual experience of the vestigial and often decaying theme parks he visited in the United States in 2007, such as Coney Island's 'Spookarama'

Figure 4. Joel Zika, *At Night* #1, 2005. Courtesy of the artist.

and the 'Old Mill' at Kennywood in Pittsburgh. In this sense the dark ride as a form of neo-Baroque representation, captured acutely in the *At Night* series, is the final, decadent flourish of a medium that would be succeeded by the cinema, the residue of a once former glory that still retains the power to unnerve and disturb.

Installed as a panorama of four images, *At Night* is immediately conspicuous for its absence of the human form. This immediately and uncomfortably situates the spectator as the focal point of view of the work. The first image reveals the facet of what appears to be an art deco façade of a building partially concealed by fog and the silhouette of a tree brightly illuminated from behind by an unseen source.<sup>3</sup> Next to it a sharply illuminated portico or entrance (not dissimilar to those of *Inferno* and *Terrorium*) manages to outshine the strong backlight of the previous image, though its saturation is still present in the casting of the winter trees as flattened out stencils in the foreground. In the third image a vulnerable distance seems to have been placed between the viewer and the environment of the previous two. We are somewhere else and there's no one else around. An old trolley car sits becalmed, but also seems out of place. Why is it here, as if concealed among the trees? The sharp light it seems to have absorbed is so clear that it reflects its own sienna hue onto the trees that conceal it, staining them a deep blood red. As if this drama of light, reflection and tension has been too much to bear, the final image of a tree in leaf brings some relief, though its complete lack of placement in any kind of identifiable landscape is still cause for concern.



The drama of this sequence of four modest images lies in its ambivalence. It at once resonates with the signs and atmosphere of charged expectation, as well as the desire to be frightened. A rudimentary journey into an uneasy heart of darkness guides the eye from the approach to the threshold moment of anticipation, the culmination of the ride and the return to the world of nature that is comfortably beyond the fabricated terror that brought you here in the first place. Certainly my own experience of this work in situ came with the uneasy intimation that I seemed to be the only living thing in the scene (despite the fact that there were other people in the gallery); an uncanny sensation generated by the subtle vanishing points of light in each image that insinuated that my gaze was its solitary locus. But more viscerally there is a compelling sense of presence. Alain Robbe-Grillet famously described the experience of Samuel Beckett's dramatic works in terms of presence,

the overwhelming sensation that you are '*on stage*', you are '*there*' (Robbe-Grillet 1965: 111). The same is true of *At Night*. Whether you like it or not, you are not an aloof spectator. This sensation of being there has gone by many names in visual and dramatic aesthetics, such as identification, agency and empathy. For Heidegger, as Robbe-Grillet reminds us, '*to be there*' is the human condition itself. But it is also the psychopathology of what we today understand as immersion in virtual space, from installation environments to digital images. Writing in the mid-1950s Beckett himself talked about 'the power of the text to claw' (Beckett 1962: 183), a potently tactile image that reminds us that imagined or simulated presence is ultimately concerned with affect. T. S. Eliot, writing at a time when pre-cinematic projection media were familiar and still in use, captured this somatic quality of our engagement with phantoms of light in a decisive line from 'The Love Song of J. Alfred Prufrock' (1917): 'But

Figure 5. Joel Zika, *At Night* # 3, 2005. Courtesy of the artist.

Figure 6. Joel Zika, *At Night* # 4, 2005. Courtesy of the artist.



Figure 7. Joel Zika, *Façade*, 2006. Courtesy of the artist.

Figure 8. Joel Zika, *Night and Morning*, 2008. Courtesy of the artist.

clunky 'pretzel' contraptions were holistic mixed media and multi-sensory experiences. The visceral nature of movement, the force of air through the hair, sound, smell and tactility meant that for a short time out-of-time, you can experience dread. In his photomedia work Zika exploits the synaesthesia of digital light to attune the senses to other channels of information to create this sense of discomfiture.

The iconic image of a death's head in *Façade* or a fourteenth century Taddeo di Bartolo-inspired Lucifer inviting you into the depths of his bowels in *Night and Morning* are figurative encounters with familiar images of dread. Their familiarity presumes a palatable distance, a kind of narcosis and a measure of safe horror that representations have always provided (what Aristotle understood as catharsis).

But *At Night* doesn't allow such a release valve. What happened at the moment when that anonymous figure went beyond the threshold in *Façade*? Or more dramatically, when the young girl in *Arcade* took what would seem to have been a fatal step









Figure 1. 'Plan of the Panopticon', 1843 (originally 1791). From The Works of Jeremy Bentham. Vol. IV, 172-3. Image courtesy Wikimedia Commons, accessed 2 March, 2014. <http://en.wikipedia.org/wiki/File:Panopticon.jpg>.

Figure 1 shows a layout of Bentham's Panopticon; however it could easily serve as an infographic of the IT department's recommendations for the \$10 million media centre built on my university's campus in 2013. These recommendations included a newly proposed 'information security policy' that would require faculty to observe a 'clean desk' policy, provide an inventory of everything on our laptops, and to ask permission to take them home at night. The insouciance with which we yoke the incompatible words 'new media' and 'centre' into the same phrase shows how persistent pan-optic attitudes remain.

Of course, 'digital' light is not a single sun in the sky shining down to provide chiaroscuro for Renaissance painters or backlighting for Panopticon wardens; it is a dispersed array of handycams, Webcams, phonecams, dronecams and software agents like face-recognition

bots. Yet in spite of digital light being more dispersed it is also less trustworthy, as evidenced by the ease of manipulating a digital image through Photoshop. If Descartes were alive today, he would have to write: 'Whatever is revealed to me by *unnatural* light ... cannot in any way be trusted'.

If that is true, then why is digital light still ascribed the power to control that Descartes originally attributed to natural light? As we move out of a broadcast paradigm and into a network paradigm, those metaphors of vision and its attendant radial model of information gathering and dissemination are increasingly irrelevant for a world lit not by a single light source in the heavens, but by a billion strands of interlinked fibre optics and Wifi networks. The metaphor of light endures because it slides conveniently into a metaphysics of asymmetry, which happens to be a very convenient metaphysics for government officials, university administrators, CEOs, or anyone who wants to remain in the position of power that he or she occupies.









Figure 2. Partial map of the Internet based on the 15 January, 2005 data found on opte.org. Each node represents an IP address, with longer lines indicating longer delays in transmission between the nodes. Courtesy of Wikimedia Commons, accessed 2 March, 2014. [http://en.wikipedia.org/wiki/File:Internet\\_map\\_1024\\_-\\_transparent.png](http://en.wikipedia.org/wiki/File:Internet_map_1024_-_transparent.png).

of its members have chosen as their emblem the cicada (Lipinski 2012), an insect that emerges from the soil every few years to make a ruckus and then buries itself underground again. A more fitting mascot might be the mycelium, the fungal root structure that can live thousands of years and extend nearly ten square kilometres.<sup>6</sup> (It's no coincidence that maps of the Internet's own 'series of tubes' plumbed by researchers like Bill Cheswick bear a striking resemblance to the mycelium's rhizomatic branches, as figure 2 illustrates.<sup>7</sup>) Despite their shadowy reputation neither mycelia nor Anonymous are loners. Fungal roots stretch from tree to tree, passing nutrients and environmental information to an entire ecosystem of symbiotic flora. The hackers of Anonymous likewise operate autonomously yet coalesce around popular causes promoted online in forums like 4chan.

## Strategy 2. Blind Them With Light

In 1993 Jennifer Ringley of JenniCam had chosen the opposite strategy to hack the Panopticon: By setting up a Webcam and leaving it on 24/7 for seven years, she flooded the Web with unedited images of her everyday moments.<sup>8</sup> While Ringley did not censor any of the 'footage' conveyed by her always-on Webcam, voyeurs keen on catching Ringley in a state of undress or in an intimate moment with a sexual partner were thwarted by the sheer volume of scenic data captured by the stationary lens. In this case, complete visual access proved an effective if ironic barrier to prying eyes, forcing would-be Peeping Toms to confront quotidian moments in a real girl's life, from brushing hair to sleeping to staring at a computer screen.

One year before Ringley retired her Webcam, Hasan Elahi became Ringley's successor, employing a more political strategy in response to US government

insinuations that he was a terrorist. Rather than conceal his private information from Big Brother, Elahi decided to leak everything about his life publicly, via a Website that obsessively documents every plane he takes, every hamburger he eats, every toilet he pees in. Unfortunately, while these floodlights on quotidian behaviour may have been radical in their day, the subsequent launch of Facebook and Twitter showed that most netizens are happy to broadcast intimate details of their lives without political or aesthetic motivation, to the commercial benefit of data-miners.

The British surveillance agency GCHQ's secret harvest of Webcam images of millions of Yahoo users not suspected of wrongdoing between 2008 and 2010 provides a less deliberate, but equally delicious instance of Elahi's visual noise drowning out the signal. Predictably enough, the project title, Optic Nerve, embodied yet another panoptic metaphor. The neural allusion in this codename aptly reflects the networked aspect of the project, which enabled spooks to sniff out and capture Webcam data packets as they routed through the Internet. The project's ambition to emulate the 'optical' capabilities of a human spy might be forgiven since the word *spy* means 'to look at'; yet the facial recognition software deployed by Optic Nerve failed to anticipate the large quantities of Webcam flesh that wasn't part of someone's face.<sup>9</sup>

### Strategy 3. Light Up Your Path

Mobile technologies are like a Panopticon on wheels, which is why Richard Stallman won't even carry a cell phone. German Green Party politician Malte Spitz had to take Deutsche Telekom to court to learn that his carrier had recorded his GPS position 35,000 times in a six-month period. Google Street View even captured a privacy advocate stepping out of his office at the Electronic Frontier Foundation to sneak a cigarette. Whereas the Panopticon surveilled its subjects from a central watchtower, devices like tablets, smartphones, and fitness bracelets track their subjects

Figure 3. Tracking data recorded by the author's iPhone during a layover in the Philadelphia International Airport on 19 January, 2011. The data was 'unearthed' using the free forensic tool provided by researchers Alasdair Allan and Pete Warden (Fenton 2011).

Figure 4. John Bell, *Octris* (op 1 capriccio for bells and space), 2010, audiovisual virtual reality installation.

as they move through a dispersed global network of ski slopes, subways, and airports (see fig. 3).

In an evocative response, Ze Frank invited people to use Google Street View to follow a remembered route they used to walk in childhood and then note down their emotional reactions. Frank's intervention is more targeted than the 'flood everything' model of Ringley and Elahi, though of course his participants are just giving Google more information on themselves. Nevertheless Frank's 'if you can't beat 'em join 'em' strategy suggests

that data mined by impersonal corporations can be repurposed to new ends—in this case, to remind citizens of the hometown roots from which a globalized economy has detached them.

#### Strategy 4. Light Up a Decoy

Heath Bunting's anamorphic photos designed to fool security cameras and fake-identity services like Tracenoiser aim to chaff the network, distracting would-be data-miners with fake information. While Ringley and Elahi also injected additional information about themselves into the network, theirs was accurate; the ersatz homepages created by Tracenoiser are a pack of lies, each a different, algorithmically created misrepresentation of its subject. But those who fly close to the sun have to take care not to get burned. The Security Camera Players were a group of actors who acted out scenes for the benefit of security guards in front of cameras in public spaces, until one of their lead actors was himself compromised by a hidden camera even he didn't see.

#### Strategy 5. Tunnel from Light to Dark

John Bell's *Octris* (see fig. 4) is a Virtual Reality version of Tetris that uses musical chords as cues for which falling puzzle pieces fit where.<sup>10</sup> While originally designed with blind spatial engineer Nick Giudice as its audience, the work also trains sighted players to listen for acoustic matches by slowly dimming the light as they level-up the game. Instead of judging visually that an L-shaped puzzle piece should be



# YOU CAN'T STOP TIME...



**But you can turn it back  
one hour at 2 a.m. on Oct. 28  
when daylight-saving time  
ends and standard time begins.**

Figure 5. A 2001 US public service advertisement that reminded people to adjust their clocks. Image courtesy Wikimedia Commons, accessed 2 March, 2014. <http://en.wikipedia.org/wiki/File:Daylightsavings.svg>.

resist the temptation of whitewashing a wiki to suit their PR needs, as studies of corporate influence in Wikipedia confirm. In this case, the edits made to this wiki are visible in the page's history, and Jeremijenko built the site with plans to highlight such changes in order to draw attention to corporate cover-ups.

## Strategy 8. Point Out Cracks in the Light Bulb

The presumption that light conveys information about time is one of humanity's longest-endured metaphysical equations, a carryover from an era in which all human activity was governed by circadian rhythms—that is, the sun's traversal across a particular neighbourhood's slice of the globe. As humanity's reach spread, time zones were invented to patch the increasingly unreliable equation between light and time. In the nineteenth century, the telegraph and railroad expanded the need for a consistent nonlocal time; time zones solved the contradiction between the global time of networks and the local time of sunlight by insisting that 'it's 10am your time but 7pm my time'. As technologies progressed, so did the cir-

cumstances in which the imposition of time zones on a continuous sphere proved to be completely illogical. Circadian rhythms are different for different seasons, which is why Daylight Saving Time was introduced as a corrective in the early 1900s, screwing with humanity's collective sleep cycle twice a year (and necessitating the kind of public awareness campaigns seen in figure 5). Circadian rhythms also vary by geography, which is why many nations chose not to obey Daylight Saving Time, and some closer to the poles such as Argentina, Iceland, and Russia have essentially



switched to it permanently (see fig. 6). As humanity expands its orbit beyond Earth, setting time by sunrise and sunset ceases to be meaningful at all; satellites pass through many time zones in a day, and the clock effectively stood still for Apollo astronauts en route to and from the moon.

For the 'always on' Internet, time zones are also an anachronism. In recent years, annual and regional discrepancies with time zones have played havoc with information technologies of all kinds.

Apple's iOS operating system failed to account accurately for Daylight Saving Time shifts in 2010, 2011, and 2013, causing alarms to wake European iPhone owners too late and Australian iPhone owners too early. In most cases these glitches were more inconvenient than life-threatening; however, in 2010 the US Food and Drug Administration warned that such arbitrary time shifts pose a grave danger due to the increasing dependence upon wearable medical devices for the timing of injections and similar treatments (FDA 2010). As an exercise in continuity, time zones also produce one of the most discontinuous artifices imaginable, the International Dateline—effectively a self-declared time machine in which stepping a metre east or west propels you forward or backwards 24 hours in time.<sup>11</sup> This awkward incongruity demonstrates the extent to which we are willing to give up bedrock assumptions about time in order to cling to cherished metaphors of light.<sup>12</sup>

Often among the first eager to explore metaphysical glitches, artists have exploited the anachronistic collision of time zones with global communication to creative ends. Ken Friedman's 1975 Fluxus performance *In One Year and Out the Other* instructed performers, 'On New Year's Eve, make a telephone call from one time zone to another so that you are conducting a conversation between people located in two years'.<sup>13</sup> In a similar paradigm updated to the Internet age, Curator Steve Dietz included in his 2006 exhibition *Edge Conditions* an installation by artists Jon Thomson and Alison Craighead consisting of a simple Webcam of the sky in Oceania shown in San Jose, artfully underscoring the contradictions inherent in applying the paradigm of light to the Internet under the title *Light From Tomorrow*.<sup>14</sup> Artist Shawn

Figure 6. Countries that adhere to Daylight Saving Time (blue: DST is used; orange: DST is no longer used; red: DST has never been used). Image courtesy Wikimedia Commons, accessed 2 March, 2014. <http://en.wikipedia.org/wiki/File:DaylightSaving-World-Subdivisions.png>.























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