ENSAYOS / RESEÑAS

ESSAY / REVIEWS

RENDERING DIFFERENTIALS: Introjective Architecture In The Age Of The Digital

PhD. Doreen Bernath. Architect

(INVITADA INTERNACIONAL)

Architectural Association School of Architecture, London

Lecture at the School of Architecture, University of Costa Rica, 7th August 2011 / *Conferencia en la Escuela de Arquitectura, Universidad de Costa Rica, 7 de agosto 2011.*

Publicado en RevistArquis por cortesía del autor.

Received : Jan-2013 / Accepted : Sep-2013

Abstract

This paper begins by probing the ambivalent and frequently conflicting relation between "architecture" and "picture". The polemic of forms and techniques of representation imposing its order upon the nature of architectural production is debated in relation to forces of technological transformations driven by more profound cultural imperatives. There had been a persistent divide between the projective and the pictorial in the discipline of architecture in Western tradition from C15th to late C20th. The divide is still evident at the time of the spread of digital technology in design practice since 1980s, when vector graphics took on the task of projective elaboration and raster graphics dealt with pictorial manipulation. However, by the turn of the C21st, a particular capability of digital inter-convertibility led to the incidental dissolution of the divide and the end of the projective dominance. Rendering technology returns the visualising process to the perception-based "image of substance". And at the same time the experimentation of force-dependent animate form is hinged upon the ability of visualizise differential calculations rapidly. The final part speculates on growing tendencies of pictorial materialisation and effect engineering as part of a different model of architectural production which can be called "introjective".

Key words: projective representation, pictorial representation, architectural drawing, picture, vector graphics, raster graphics, Photoshop.

Resumen

Este ensayo inicia investigando la relación ambivalente y conflictiva entre la "arquitectura" y la "pintura." La controversia en las formas y las técnicas de representación, que imponen sus ordenes sobre la naturaleza de la producción arquitectónica, se discute en relación con las fuerzas de las transformaciones tecnológicas accionadas por imperativos culturales más profundos. En la tradición occidental de la disciplina de la arquitectura, del siglo XV al siglo XX, ha existido una persistente división entre lo proyectual y lo pictórico. La división es todavía evidente en el momento de la propagación de la tecnología digital en la práctica de diseño desde los ochentas, cuando los gráficos vectoriales se hicieron cargo de la elaboración proyectual, y los gráficos en raster lidiaron con la manipulación pictórica. Sin embargo, hacia inicios del siglo XXI, una capacidad particular de inter-convertibilidad digital condujo a la disolución incidental de la división y al fin de la preponderancia de lo proyectual. La tecnología del renderizado hace que el proceso de visualizar retorne a la percepción de la "imagen de una sustancia." Y, al mismo tiempo, la experimentación en forma animada dependiente de fuerzas, está supeditada a la habilidad para visualizar cálculos diferenciales rápidamente. En el final del texto se especula sobre las crecientes tendencias en la materialización pictórica y en la ingeniería de efectos como parte de un modelo diferente de producción arquitectónica, al que puede llamarse "introyectivo."

Palabras clave: representación proyectual, representación pictórica, dibujo arquitectónico, pintura, gráficos vectoriales, gráficos en raster, Photoshop.

Act 1 •

Projective vs. Pictorial

Deeply ingrained in the Western architectural tradition is the conviction of the purity of architectural conception through projective drawings, made explicit by Le Corbusier in a public lecture in 1929:

> *Now I have appealed to your* ***sense of truth****, I should like to give you the* ***hatred of rendering****. For to render is only to cover a sheet of paper with seductive things; these are the 'styles' or the 'orders'; these are* ***fashions****. Architecture is in space, in extent, in depth, in height: it is volumes and circulation. Architecture is made* ***inside one's head.*** *The sheet of paper is useful only to fix the design, to transmit it to one's client and one's contractor. Everything is in the plan and section.* (Le Corbusier, 1991: 230)

The pictorial nature of renderings incorporating conventional imageries results in the production of 'illusions" and the risk of contaminating, vulgarising, distorting and causing error in the purity of architectural conception. Pictorial illusions and effects must be differentiated and kept apart from what he believed to be the accurate and truthful system of specialised architectural drawings: a system of line drawings, such as plans, sections, elevations, based on rules of mathematics and projections. Pictorial imageries are believed to submit the "architectural" to "non-architectural" forms of visual convention, dislodging the control of lines and projections. The segregation of the two domains, architectural as opposed to non-architectural drawings, is very clear; on one side, there is the system of line drawings which is considered to embody pure conception of the mind and to be a truthful representation of design, and on the other side, pictorial renditions which are considered to be deceptive illusions that steer viewers away from the pure conception of the mind.

The division between the architectural and the pictorial, which Le Corbusier's remark epitomised, can be traced back to the early C15th when a specific conception of architecture emerged in the context of the Italian Renaissance. Drawings in lines and angles that follow rules of mathematics and geometry were assigned a significant role, intellectually and graphically, in architecture and design, as found in the first theoretical treatise on architecture by Alberti. His proposition powerfully reduced the complex nature of building in all aspects to a singular conceptual device of "lineaments", divorced from matter and visualised through the graphical notation based on measurable and precise lines and angles:

> *It is quite possible to project whole forms in the mind without any recourse to the material, by designating and determining a fixed orientation and conjunction for the various lines and angles. Since that is the case, let lineaments be the precise and correct outline, conceived in the mind, made up of lines and angles, and perfected in the learned intellect and imagination.* (Alberti, 1988: 7).

From the moment that architecture as a discipline defined its own graphical domain, the capabilities and limitations of the chosen graphical medium in turn began to shape, imposing an order upon the idea, process and outcome of architectural production. What can or cannot be manifested through the graphical system to a large extent determines what lies within or outside of the concern of the design. The bind of the specialised territory of architecture and specialised means of drawings in lines and geometric projections became fundamental and exclusive.

The projective nature of architectural drawing has a deeper significance than simply being an issue of representation. Central to the canonical book *The Projective Cast* by the historian Robin Evans is the understanding that techniques of projection directly structure the conceptual logic of an architectural design, and , as he argues, they have in a more fundamental sense been configuring the way architecture is perceived, experienced and understood as a discipline. Evans states:

> *What connects thinking to imagination, imagination to drawing, drawing to building, and building to our eyes is projection in one guise or another, or processes that we have chosen to model on projection*. (Evans, 2000: XXXI)

The projective underpins the architectural: from the task and position of an architect, the nature of a design project, the design conception to specialised architectural drawings. Although Evans points out that many modern architectural designs since C20th have gone far beyond what can be described by the set of plans, sections, elevations and perspectives, he reveals that the joining of the conceptual basis of architectural design and projective drawing techniques has never been seriously questioned or opposed (Evans, 2000: 119).

The "picture" of a design, as opposed to projective drawings, is characterised first of all as being filled up with conventional imageries, from the use of familiar visual elements, to the conjuring of recognisable visual effects. The convention changed across different historical periods and contexts, but the pictorial representation of buildings adapted to the predominant visual form and style of its time, for instance, either emulating the popular form of easel painting in the C18th, or to appear like photographic images in the mass media of C20th. It makes references to existing realities, portrayals in common representations, while being unconcerned with principles of relative scales, proportional measurements or the mathematical and geometric properties that are inherent to projective drawings. Its pictorial construction contradicts ideals of tabula rasa, the starting condition of an empty and infinite space; it also resists the rational flow of conceptual stages implicated by the projective.

In fact, the demand for the production of pictorial representations of building designs came from outside of the architectural discipline. It was prompted by the fact that architectural drawings had become so specialised that they could not be understood by clients or the public. In order to get an impression of what the project would be like if realised, people outside the architectural profession demanded a "picture" of the design, which could be understood because of its proximity to common and conventional visual forms. The demand grew, particularly in the C18th when the number of private clienteles independently seeking professional architects rose in the European societies and the mechanism of design competition, from private to public commissions, also took shape. From the perspective of a lay audience, they were more connected with qualities of design expressed via pictorial means, rather than specialised drawings devoid of matter, texture, context and habitation. By C19th, the divide between the remit of projective design and pictorial rendering is evident in the Beaux-Arts system of architectural training, where students were taught both the skill of accurate orthogonal and perspectival projections, as well as artistic skills of rendering these drawings with light and shadow, texture and materiality, context as the background, and presence of people.

In works by Boullée and Ledoux, for instance, techniques of pictorial rendering were intentionally applied upon orthographical and perspectival drawings to express the visionary, utopic and transcendental qualities of design (Thomine- Berrada, 2008:142).

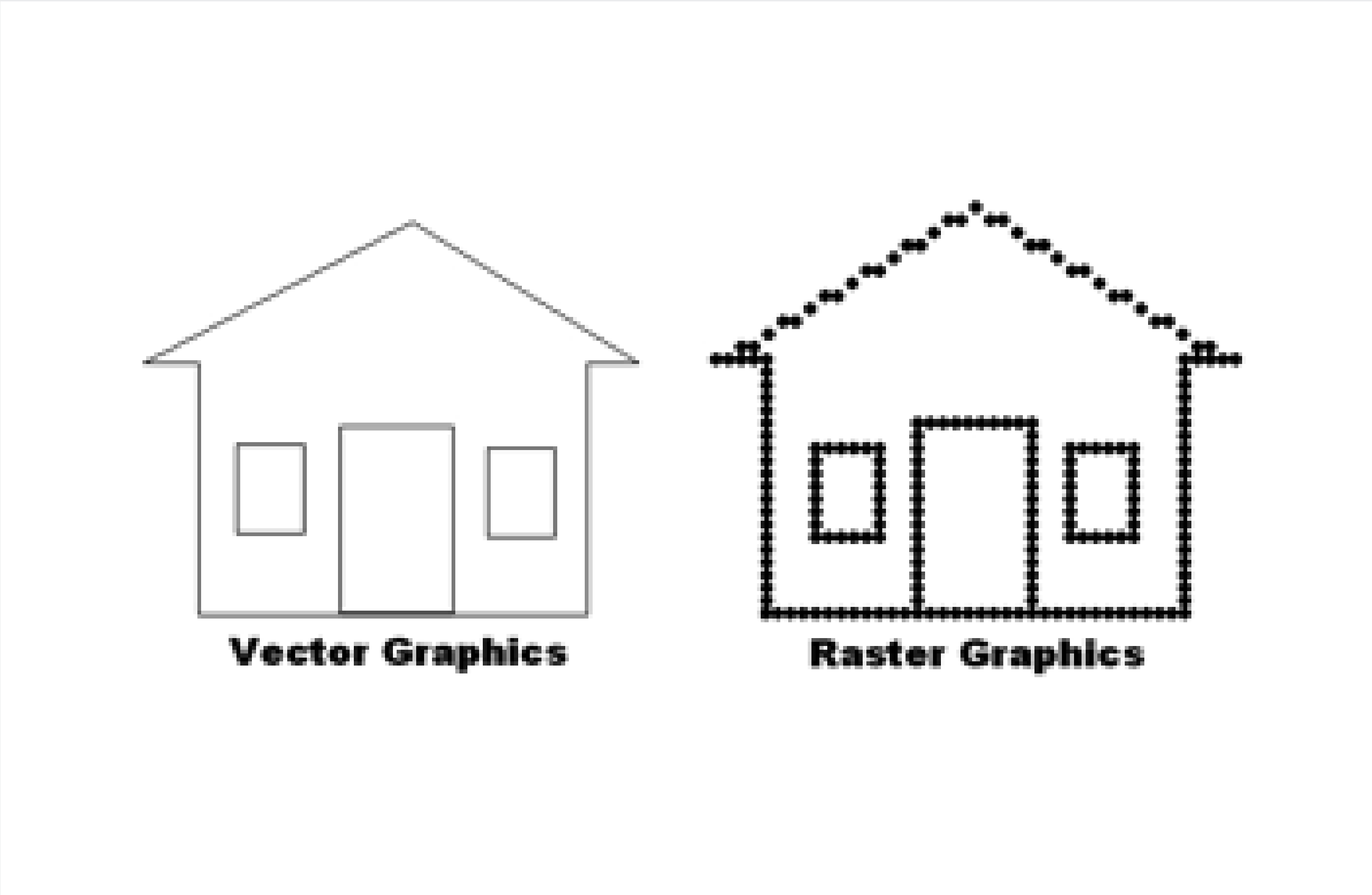
Contrary to the projective basis of the discipline of architecture in Western tradition, in a different cultural context such as China, no evident division existed historically between the practice of picture-making and the practice of architectural production. The fluidity of working simultaneously with pictorial and projective forms of drawing allows design decisions to be made based on a wide-spread pattern of pictorial thinking. Projects in contemporary Chinese practices are very often being visualised and even realised through highly effective computer renderings, known as *effect* drawings (效果圖), while representations in plans, sections and elevations become a posterior exercises of "fitting into the picture". *Effect drawings* of successful projects fill up big volumes of architectural publications in bookshops, are used as appropriate references in schools and are promoted as examples of good architectural design. The phenomenon of the love of rendering subverts established values in the projective framework posited in the Western tradition which led to misinterpretations of the nature of urban transformations and architectural production in the context of China. The phenomenon becomes the indescribable; for instance, in Koolhaas' terminology, it pertains to "chaos", "panic", "primitiveness" and "opportunistic exploitation of flukes, accidents, and imperfections" (Koolhaas, 2001: 27). The logic and consistency of pictorial thinking could not be digested within the projective model.

How architects wish to talk about their designs and what they do exactly in practice are often very different stories. While Le Corbusier publicly stressed the superiority of the projective and conceptual nature of architectural design (Wigley, 1998:26), it has been revealed that he was also obsessed with controlling pictures of his own design, routinely airbrushing photographs of his projects to remove unwanted details and to accentuate pictorial effects

(Colomina, 2000:107). The dependency on pictorial forms of representation to inspire and communicate architectural ideas has its own distinct historical trace in the Western tradition, just sidelined in the shadow of the projective discourse. The division between the projective and the pictorial persisted well into the age of the digital, where the invention of vector graphics and raster graphics dealt with the two tasks respectively and separately.

However, further sophistication of digital technology brought about the capability of interconversions between these two forms of technology and triggered a significant turn. It becomes possible to be simultaneously dealing with geometric instructions and picture-making, thereby dissolving the divide and the hierarchy between them, and changing the entire process of design in terms of logic, outcomes and meanings.

This paper discloses, as its final speculation, the provocation of picto-matter, picto-effect and picto-logy in the generation of spatial forms and contents, between the love and hatred of pictures of architecture, traversing the specialised and commonsensical, entailing cerebral and intuitive prompts, thus mounting the “introjective” shift in current digital culture of architectural design.



Act 2 •

Vector-Raster and Image of Substance

At the start of digital era, the divide of the projective and the pictorial is not disturbed, but instead, greatly amplified. When design work gradually shifted from paper to computer-based two types of visualisation systems: vector graphics became the basis of programmes such as AutoCAD or Microstation; and raster graphics became the basis of image viewing and manipulation programmes such as Photoshop or ACDSee. When introduced to the architectural profession, they modelled themselves upon the existing methods of drawings or manipulating images. These digital programmes modelled themselves upon manual methods of drawings and image manipulation in order to ease users across the transition. Hence the hybrid configuration: a user interface adapting to the habitual practice of the user, so at the same time, the complex digital operation could remain hidden and “non-interfering” to the user. For instance, when the Pen tool was pioneered by Adobe in 1987, it removed the frightful need for designers to deal with commands in the form of numbers and the programming language of digital technology. The designer is eased into the programme by the familiarity of drawing onscreen. Adobe technology further ensured that the paper print-out exactly corresponded to the computer screen through the invention of Portable Document Format (PDF). Like previous manual methods, the designer maintained direct contact with the drawn object by being able to see and work onscreen, yet at the same time, he or she is able to experience the efficiency of the computer’s capacity to transform sizes, scales and shapes, as well as many more previous unknown visual effects.

Vector graphics, since its inception in the 1950s, is the foundation of projective drawings in the digital realm. It expands the generation of space-form by means of mathematical and geometrical principles, which has long been the basis of projective process of design. The design is handled objectively and globally, and the power of computation enables much more rapid and complex geometrical transformations. Drawings in vector graphics begin by using primitive geometric entities – lines, polylines, circles, arcs, polygons, etc. – created by vectors in a virtual, homogenous, empty and infinite 3D domain. In mathematics, a vector is a quantity characterised by both a magnitude and a direction. After identifying a point of origin, the vector moves the point in the direction and magnitude (force exerted) specified to a second point, and the movement can be represented by a line segment. A vector is not a line made of a continuous trace in material terms. The line represented by a vector is by essence an indication of movement and forces, rather than a substantial entity. A line represents thetrace of a moving point, the rectangle describes multiple movement lines that join together, a solid is formed when vector movements are projected along a third coordinate of depth: a tube shape emerges when a circle is projected along another circular path in a third dimension, and so on. A vector movement is analogous to the nature of a projection, creating objects as insubstantial traces as a result of a set of mathematical operations.

The conception of "objects" defined by points, lines and surfaces, in a space defined by three perpendicular axes of coordinates, goes back to the invention of Euclidean geometry over two thousand years ago. Although many other conceptions of object and space have emerged since, the Euclidean space (later known as Cartesian space due to Descartes' major contribution in extending the Euclidean system) remained dominant in the scientific conception of the world for centuries. In the early Renaissance period, there was a renewed enthusiasm in the exploration of Euclidean geometry, in particular to the visualisation of reality and that of design. It was also the time when the empty and infinite properties of the Euclidean space became much featured and debated in the development of projective techniques in relation to the architectural discipline. Both orthographical and perspectival projections are based on an extension of the Euclidean system of conceiving and visualising design, which involves hypothetical traces of movements of light rays and lines of vision that are essentially ideal and have only "nominal" rather than real values. Hubert Damisch explains the non-substantial nature of projective drawings:

> *But linear perspective implies an extra reduction, the reduction of the visual faculty to a single point – from which the whole series of its elements are engendered: point/line/surface/, elements that, although they serve a rational construction, nevertheless have no value in reality... It reduces bodies to surfaces defined by the outline by which they are represented from a predetermine point of view, no account being taken of the fact that those 'points', 'lines', and 'surfaces' [check] have no more than a nominal existence... A surface is a limit: it is not part of those bodies, merely their common frontier, the point of contact (contingenzia) of their extremities. When referred to the element upon which vision is operating, the surface has a name, but no substance (Damisch, 2002: 135).*

Damisch is referencing to Leonardo da Vinci's distinction of "form" defined by outlines being less powerful than "colour", which in turn is less powerful than "substance", or "image of substance" [similitudine corporea] (Leonardo da Vinci, 1939:210). Damisch points out that Leonardo's starting point with perception, rather than just geometry, "bring to light all that was implied by Alberti"s system, and at the same time criticise it." Accordingly, the depiction of "substance" is understood as something that fills everything (indiscriminate of bodies, objects, spaces between objects, etc.) and flows from one to another continuously; while "form" emerges only when this continuity is broken by a hypothetical line or surface, which in itself has no substantial value but only as a nominal device that outlines, separates and empties bodies, objects and spaces[11] (Leonardo da Vinci, 1939:126). An existence of no depth, at the occurrence of a hypothetical divide of an outside and an inside, as Becket pondered in his writing *The Unnamable*:

> *There is an outside and an inside, and myself in the middle, this is perhaps what I am, the thing that divides the world in two, on one side the out-side, on the other the inside, it can be thin like a blade, I am neither on one side nor on the other, I am in the middle, I am the wall, I have two faces and no depth*[11]. (Teyssot, 2000)

The relationship of an outside and an inside, the projection of objects and spaces, begins with the hypothesis of a middle of two faces and no depth, a device of nominal differentiation, the mark of the finite as oppose to the infinite.

This is the basis of vector graphics, which is why vector graphics files tend to be relatively small (in comparison to raster graphics) and can be transformed because they only need to save information on origin points and extents of movement to define all outlines and surfaces. The efficiency of vector graphics to handle geometric forms and mathematical calculations has been much exploited by designers since it becoming available through the popularisation of desk-top computers in the 1980s.

A further advantage of vector graphics is that since all information of outlines and surfaces are stored as mathematical formulae, they are scale-independent, meaning that these outlines and surfaces can be displayed orprinted at any scale without compromising precision or level of resolution. The visualisation of these formulae obeys rules internal to principles of projective geometries, hence the core definition of these "forms" can remain universal at every scale of representation, because they do not need to describe anything outside of this system, i.e. of "colour" or of "substance". One important implication of this scaleless universality of mathematical formulae in vector graphics is that all "form" definitions of the design project are contained in one master file: a master 3D geometric model in vector graphics. The file integrates and encompasses all objective information of the design based on mathematical formulae. Subsequent representations in plans, sections, elevations and perspective views are all derived from this one master file (Carpo, M., Lemerle, F 2008:4). This actually inverts the traditional projective method of deriving a 3D representational model based on information worked out by means of 2D plans, sections and elevations. Before the digital era, no master model could be made visible to continually respond to the development of the design, except in the mind of the master designer. So the visualisation of the project as it develops had to rely on 2D delineation in projective plans, sections, elevations and perspectives, which are all partial approximates to certain aspects of the master model inside the mind of the designer. The inverted process brought about by digital technology meant that the master model in vector graphics became the singular reference towards which all design information converges. The 3D layout of design is no longer confined to the imagination of the designer, but externalised and made visible; it rules over other partial and subsidiary representations in plans, sections and elevations.

Contrary to the insubstantial nature of vector graphics, raster graphics is characterised by the impression of different visual information of colours and light upon a flat substantial surface full of pixels. The technology of raster graphics leaped forward in the 1980s, most notably through the development of "device-independent language" by Adobe and the introduction of software such as Illustrator and Photoshop (Pfiffner, 2003:23). To draw on raster graphics is to give continuous definitions to each and every pixel along the length of a line or across the spread of a surface. The setup of a uniform spread of pixels upon a surface is akin to the "grain" of photographic negatives and light-sensitive print papers, where each grain holds a unit of chemical reaction that records colours and light. In a master class, the photographer Diane Arbus describes the "grain" as

> *...a kind of tapestry of all these little dots and everything would be translated into this medium of dots. Skin would be the same as water would be the same as sky...*

Returning to Leonardo's premises, raster graphics deals with aspects of "colour" and "substance" as substantial and continuous imprints, rather than nominal outlines of "form" defined through mathematical formulae in a vacuous space. Bodies, objects, spaces between objects, and so on, are all indiscriminately filled and registered as pixels.

A more powerful function of raster graphics is the capacity to bring in images from existing sources to work on, like the process of cutting and pasting of a collage. This involves first the digitisation of original images so that all share a uniform basis of pixels which then can be digitally combined and manipulated. Given the nature of this tapestry of pixels and the manipulation process involving each and every grain, raster graphics files tend to be much larger than vector graphics files when attempting to visualise a certain aspect of the same design. Moreover, raster graphics do not deal with design objectively or globally, but picture the nature of design from a localised and selected point of view. A particular relation between the design and its contextual realities is articulated pictorially.

Raster graphics operates within the domain of picture-making and is concerned with strategies of visual effects, connecting across various forms of media production, from graphics, films to animations. When architectural designs engage representations through raster graphics, they are involved with techniques, resources and styles that have originated in other domains of visual media production. Vector graphics empty out and reduce design information to outlines of forms defined mathematically; raster graphics fills up the visualisation of design with "images of substance" (*la similitudine* *corporea*) that belong to this shared domain of visual media and effects. This "image of substance" again refers to just that which has been excluded from the system of projective drawings. Damisch further explains the "image of substance" through reference to Leonardo's interest in the depiction of effects, or "atmospheric phenomena":

> *Generated by distance (or by too great a proximity), by darkness, or by mistiness, sfumato (gradation) and the mezzo confuso (chiaroscuro) operate in such a way that the outlines of objects no longer stand out from the atmosphere, which now appears as the most fundamental element in the representation.* (Damisch, 2002: 138)

Atmosphere and effects are both expressed in the suffusion of substance through bodies and air without boundaries. Leonardo is aware of the way such exploration, especially in the depiction of the wind, clouds, storms and rains, upsets the reduction in the order of the projective system. In studying the depiction of wind, Leonardo writes:

> *...it is not the motion of the wind but only the motion of the things carried along by it which is seen in the air.* (Leonardo da Vinci, 1939:168)

He makes a distinction between the visualisation of the wind per se as an object in motion and the visualisation of things moved by the wind. The latter can only be achieved through the understanding that air is not an empty space but is filled with substance, which has the effect of carrying other things along with its movements. Every bit of this filled gust of air is charged and reflects the effect of movement, thus making visible the presence of wind in the air. Another point Leonardo makes is in identifying and situating a receiver of the atmospheric effect, which is expressed in the way he describes the motion of things as "seen" in the air. Both the filled substance and the emanating effect of movement do not exist in isolation but hinge upon the presence of someone that perceives them; in other words, the visualisation anticipates the senses of the viewer rather than by separating objective visualisation from the perception of colours and substances. The suffusion of substance, the depiction of effect and the engagement of a receiver of the effect characterises raster graphics visualisation. The spread of pixels recording light and colours in raster graphics corresponds to this notion of depicting reality as substances that are continuous: objects are indistinguishable from spaces, surfaces are indistinguishable from bodies, and as Arbus describes, "skin would be the same as water would be the same as sky."

Act 3 •

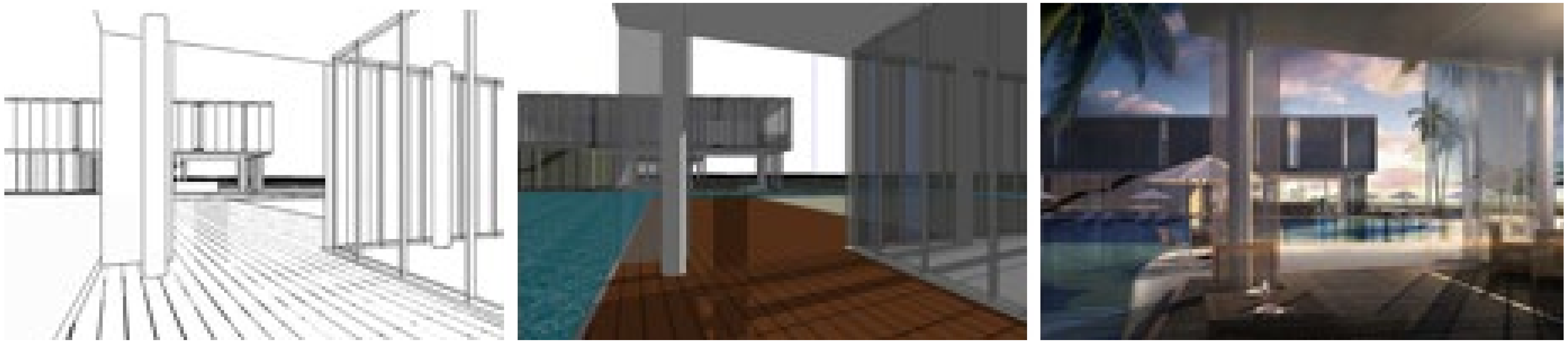
Pictorial Materialisation and Visualising Differentials

A rasterised picture of design, commonly known as a digital rendering, is often generated via a three-step process: 3D modelling (vector graphics), model rendering (converting vector to raster) and photoshopping (raster graphics).

Firstly, a specific view of the vector model is chosen, then upon this skeleton of nominal lines, calculations are made to add information to the chosen view, such as the direction and intensity of sunlight, resulting shadows, levels of transparency and reflections of surfaces, application of material textures, visible details, and so on. The crucial middle step of model rendering attempts to marry the precise but insubstantial mathematical in vector graphics with the "image of substance" offered by raster graphics. Perceivable qualities initially expelled from projective drawings now invade the empty hypothetical space in the vector domain, as Evans unravels:

> *Reflection, lustre, refraction, luminosity, darkness, colour, softness, absorption, liquidity, atmospheric density, instability of shape: these and a host of other properties jeopardize perceptions of metric uniformity.* (Evans, 2000: 353)

As substantial presence fills up the picture pixel by pixel, the nominal existence of a middle with no depth in an empty space dissolves. A hypothetical mathematical construct acquires a sense of reality by rendering perceivable and familiar details and effects. Moreover, with this step, the visualisation of the design no longer deals with the totality of the object in question, but rather it is restricted and conditioned by localised circumstances of perception – "that which is seen". Calculations in the



conversion step are concerned only with what is relevant from a particular chosen point of view of the perceiver in relation to the design object.

This conversion step of model rendering achieves, firstly, visual effectsof design through digital calculations, thus extending the sense of scientific accuracy from the initial vector model to the resulting raster image. Secondly, it situates the design in the realm of the pictorial where visualisation no longer follows mathematical principles, but shifts to follow the eye of the picture-maker and the conventions rooted in the popular visual culture. The combination of the two produces an image that brings together the subjective criterion of seeing, yet at the same time carries a perceived sense of scientific accuracy. For instance, when attributing different levels of transparency and reflectivity of glass to a surface in a vector model, a rendering software works by filling the empty surface with visual information that in some way relates to the conventional depiction of glass under specific circumstances of light and location. Is the glass outside on a façade? Is the glass indoors as a partition? Is the glass part of a display? To supply appropriate visual information to these situations, a rendering software is normally organised through offering a stock of “textures” and controls of sizes, colours, transparency, reflectance, etc. that the picture-maker can see, apply and adjust. These textures are digitised visual effects of “that which is seen”: effects of substances that perceivers can relate to as part of their everyday experiences. Rendering software relies on existing examples of the material and qualitative depictions as important references of conviction. Advanced rendering software takes pride in being able to achieve a close resemblance of photo-realistic effects made possible through rapid digital calculations.

In practical terms, there are limits to the capacity of computer and software programmes which restrict the number of calculations that can be carried out to display all necessary visual effects on all surfaces across the model. The final outcome of a model rendering process, from expressions of materiality, indication of light and shadow, to traces of habitation, would still appear crude to common perception. Adjustments and more desirable effects are added after the model rendering process, described as “post-production” (a term used commonly within the rendering industry), by software which handles raster graphics directly. Photoshop is widely used to bring a convincing life to the rendered picture, a flatten 2D configuration, by means of focusing the presence of the design from a selected and limited point of view relative to a set of localised, everyday conditions.

With the ever-increasing computational power supporting rendering software, it is becoming possible in the first decade of the C21st to achieve realistic pictorial effects of substance and light globally across the vector model. Consequently, the distinct three-step process of rendering is compressed into one simultaneous state of developing vector model and visualising it as rasterised picture. In fact, the whole three-step rendering process can now be reversed, for instance, via new technology of

Photosynth launched since 2007. Digital technology has developed to be able to rasterise vector graphics, and at the same time, to vectorise raster graphics. Mutual "interconversion" is a new digital capability: rasterisation and vectorisation (paper-to-CAD conversion, GIS images vectorised to create maps, etc.). Rasterisation is the means by which a vector model is turned into a flattened picture, whereas vectorisation is the means by which a picture can be turned into a vector model, i.e. becoming a mathematical construct in the empty and infinite Cartesian space. Insofar as vector and raster graphics fit into separate domains of the projective and that of the pictorial, the occurrence of a direct digital interconversion between these two domains is something new and challenges their traditional separation. Design is now taking shape through a visualisation process that produces images that are results of accurate scientific calculations and images that are related to everyday visual experiences. Design is taking place in a digital realm that amalgamates the projective and the pictorial.

Consequently, the nature of "form" and "space" is changing entirely with the coming together of nominal projections and "image of substance". On the one hand, the continuity of substance inherent in rasterised renderings is pushing the initial empty demarcation of form and space towards a quality of materialisation. On the other hand, the notion that substance is continuous is linked to the notion of force being continuous, traversing things and spaces. This is akin to the way Leonardo da Vinci describes wind not in terms of the movement of air itself, but the movement of "things carried along by it", the force that is manifested through its effect upon the substance. The nature of "form" and "space" is no longer a matter of nominal points, lines and surfaces, but a manifestation of a continuous substance (also understood as a field or topography) acted upon by a set of forces (also understood as conditions or parameters) which varies the characteristics of the substance (from shape, texture, quality, and dynamic to interaction).

The buzz in digital design culture about the idea of a continuity in matter as a "force" began with Deleuze's elaboration of the "fold" based on Leibniz's proposition of continuity consisting of an infinite, indivisible number of folds. Continuity resides in the flow and variation of folds or bending movements, which are manifestations of the flow and variation of forces. Leibniz developed his idea of the "fold" in the C17th based on his advancement of differential calculus in mathematics, later on the basis of his theory of "monads" which he proposed to be fundamental units in the metaphysical realm that are both substantial forms as well as centres of force. Deleuze expands on Leibniz's belief that substance is force; and that form came as a result of actions exerted by internal and surrounding forces. Deleuze writes:

> *That is what Leibniz explains in an extraordinary piece of writing... a continuous labyrinth is not a line dissolving into independent points, as flowing sand might dissolve into grains, but resembles a sheet of paper divided into infinite folds or separated into bending movements, each one determined by the consistent or conspiring surroundings.* (Deleuze 2006:6)

Deleuze's ideas were picked up by designers and design theorists in the 1990s as a new direction in the conception of form and space. Most notably was Peter Eisenman's reading of Deleuze which led to an exploration of "folding" as a generative process which is different to folding as visible form. Later on, Greg Lynn's idea of an "animate form" propels a greater tendency towards making curvilinear fold-like forms, which he believes is

> *...defined by the co-presence of motion and force at the moment of formal conception. Form is an initial condition, the cause of both motion and the particular inflections of a form.* (Lynn 1999:11)

By the turn of the C21st, the connection between substance as force and architecture as a dynamic flowing form responding to varying forces is well established as a new design approach, relying on advancing software dealing simultaneously with vector calculations and rendered effects. Lynn acknowledges that contemporary animation and special-effects software are now indispensable as design tools. Although buildings in most cases cannot flow as air and water do, the fantasy of movement in new architectural design attempts to, as Lynne argues, embed or store memory of forces, responding to contextual conditions and performance requirements, in the shape of the building form. Previously invisible traces of forces within bodies and objects, such as stress and bending movements of building structure revealed through x-ray-like diagrams in different shades of colours to differentiate levels of forces, are now becoming a new form in themselves. This runs parallel to the logic of differential calculus, which concerns the finding of "derivatives", a measure of the rate of change derived from an original mathematical function, revealing properties within the original function, from motion, velocity, acceleration, to maximum/minimum change, etc. Design discourses in the new millennium are severing the dependency of the derivative from the original function or shape and giving it a perceivable form and presence. Today, the question of formation is about the visualisation and effect of forces previously invisible in objects. Velocity diagrams, structural stress diagrams, movement diagrams and performance diagrams are manifestations of potential building form in their own right.

Since the flow of forces has no edges, no breaks, no boundaries, only variations in strength and behaviour – differentials and folds in Leibniz and Deleuze's terminology – the outcome in formation tends towards the curvilinear. Lynn argues for the inevitable rise curvilinearity, a more sophisticated and complex form of organisation, because "inflection, or continuous curvature is the graphical and mathematical model for the imbrication of multiple forces in time." (Lynn 1999:23). The perception of curvature and the concept of multiple potentials of forces are now aligned; the notion of "animate form" prescribes not only the conceptual shift from the concern of static geometry to the multivalence of dynamic motion through calculus, but also the technical tools that enable such visualisation and formation. Designers are not mathematicians and cannot work purely via numerical systems; they are driven by the belief in a mathematical model that enables dynamic forces to shape forms, but ultimately the conviction lies in an effective model of visualisation that transmits fully the sense of promised dynamism. The visual qualities of computer-generated images are important; visualisation enables intuitive recognition of dynamic patterns and responses in design decisions. Lynn emphasises this point through the story of Rob Shaw and Doyne Farmer, the first people to map the non-periodic behaviour in a dripping faucet, who spent thousands of hours in front of a computer screen watching visualisations of chaotic equations as a method of training oneself to recognise those same behaviours intuitively. It becomes intrinsic to digital culture to develop both advanced systems of calculations and methods of visualisations, from manifestation of changing forces to effects of formation.

The principle of substance as force demands the visualisation of the formation process not as an abstracted mathematical construct within the traditional conception of an empty and infinite Cartesian space, but as actual matter upon which forces exert the effect of transformation. One popular strategy is to treat the condition of continuous substance as a kind of a continuous ground or field which becomes the topological medium of the fold. Mathematically, the effect of continuity of substance is achieved by a continuous spread of vectors across this topological surface that reacts and deforms according to the assertion of forces. Substantial qualities, in terms of weight, density, elasticity, porosity, reflectivity, and so on, are set as conditions and criteria governing the vector points and revealed both through the differential responses to forces, as well as changes in the rendered effect of substance.

We are entering the age of the aerodynamic teapot. It can embody memories of the optimal responses of a multiplicity of possible positions and functions, like a sailboat hull, as Lynn would argue(Lynn 1999:18). Yet the actual animate form does not so much improve the performance of the teapot in a dynamic sense, but rather, effective in making the teapot like something else, allowing it a moment of suspension from its ordinary identity, and implying associations with other curvilinear forms, to be like a dynamic machine or flower petals, evoking feelings of flow, speed, flexibility and softness. The force-substance differentials displace the original form and imprint a new form; attributes deviate to become objects; embodying not only the effect of vectorial energies, but references of likeness to something other than itself and of the order of immediate association and commonsensical imagination.

Act 4 •

Introjective Cast: Substance, Effect And Reference

> *And as the geometrician reduces every area circumscribed by lines to the square and every body to the cube; and arithmetic does likewise with the cubic and square roots, those two sciences do not extend beyond the study of continuous and discontinuous quantities; but they do not deal with the quality of things which constitute the beauty of the works of nature and the ornament of the world (Leonardo da Vinci 2008:122).*

Wind, mist, cloud and deluge, those natural phenomena intensely studied by Leonardo da Vinci, epitomised the conscious resistance to reducing representations of the world to quantities in the system of nominal projections of geometrician and arithmetician. Of the three aspects of perspective to human eyes, in Leonardo's own system of representations of the world, substance remains more powerful than colour, and colour more powerful than form, yet across the next five centuries after his time, the perspective of form as outlines overshadowed the other two aspects and established itself at the core of the architectural discipline as the regime of pure projection and pure space, cumulated in Evan's "projective cast". In the same way as the technique of printing became imperative to the dominance of line drawings, enabling precise reproduction and dissemination of architectural ideals, the transition into the age of the digital enables a different set of ideals, such as discourses on force-substance and motion-form, to become imperative to architectural production at the turn of the C21st. Certain technical capabilities would only blossom when met with a favourable cultural condition, as Mario Carpo reveals, hence the revolution brought about by the particular capability of "interconversion" within digital set-up is not necessarily intentional, but should be understood as incidental (Carpo 2001:7). The amalgamation of vector-raster, the instrumental role of the rendering technology, dissolved the five-century old divide of the projective and the pictorial, and became imperative to the return of the image of substance in architectural production. The increasingly powerful digital handling of mathematical calculations, on the one hand, enables more complex vectorial forms to be rapidly generated, and on the other hand removes the need for designers to deal directly with numbers and geometries, but instead, with implications and effects of these calculations. This tendency has been met with ideas of differentials, continuous fold and substance as force, returning to an understanding of form as flow of substance that embraces qualitative effects perceivable to the senses.

The tempest returns to brew in the outline. The new focus in digital design culture is the marriage of vectorial calculations with rendered effect. It changes the nature of form and space entirely in the architectural production. These entities are no longer nominal and static, but instead, they are substantial and dynamic. Form and space, as much as imagination runs in the current digital culture, are to be as ephemeral, forceful and changeable as wind, mist, cloud and deluge.

The late 1990s saw the rise of the idea of an effect, a phenomena in Leonardo's sense, as the driving imagination of an architectural project. This trend of design approach has been directly connected with the evermore rapid and powerful rendering technology in the digital realm, supported by the ready conversion between rasterised effect and precise vectorial information. Digital rendering became the powerful medium between the necessary technical resolution of a built object and the dramatic play of pictorial effect, the conjuring of substances, materiality, light-shadow, colours, movements, action, force, flow, fold, etc. In 2002, architects Diller and Scofidio created "Blur", a project of an inhabitable cloud whirling above Lake Neuchatel in Switzerland. It is an example of an architectural construct explored as an effect, a pure phenomenon. Such is the way that an architectural "blur" contradicts the rule of projection, as Damisch ponders in the fable of the disappearance of architecture:

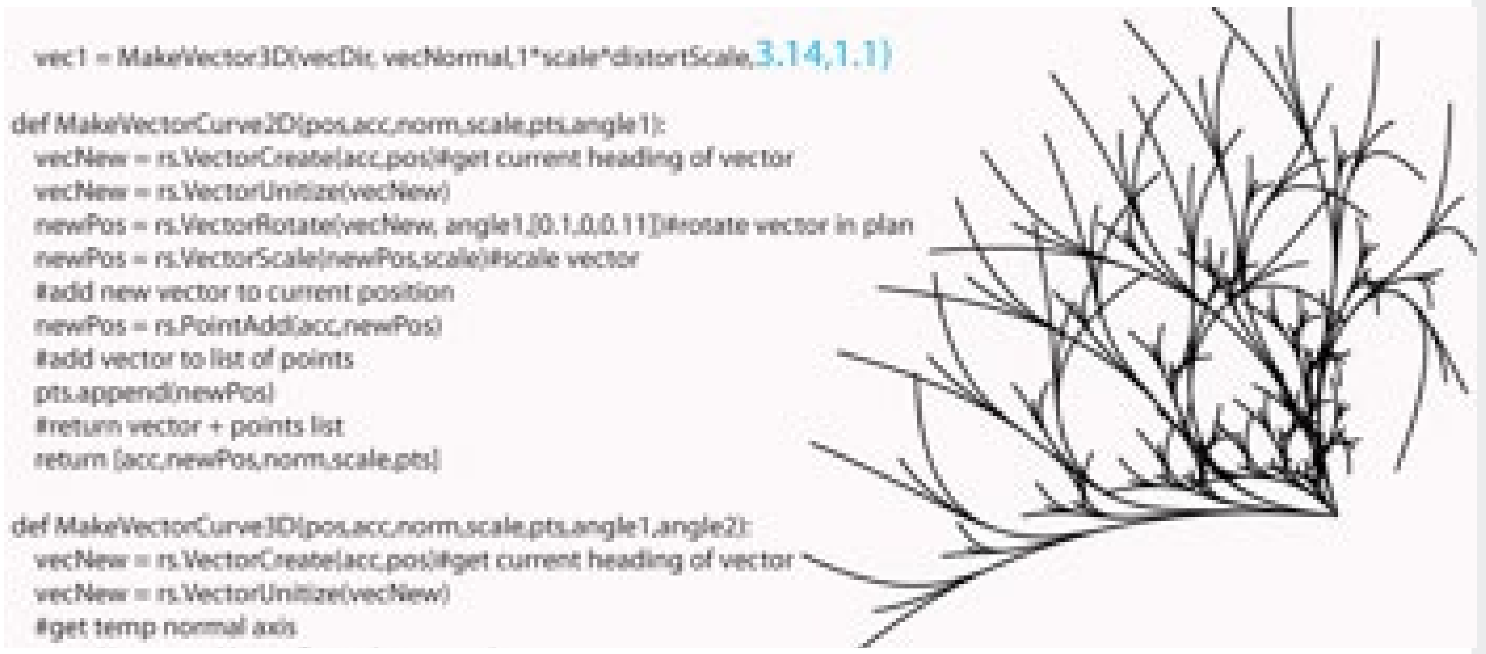
> *...from the moment the cloud becomes a phenomenon – phenomenon, not object – that it eludes all intentional purposes along with any essentialist position, having only an accidental and transitory presence and being a function of strictly external causes and conditions, leaving us, moreover, completely free to project our fantasies on to it (Damisch 2003:9).*

Diller and Scofidio's design statement 2002 describe the Blur as "an architecture of atmosphere – a fog mass resulting from natural and manmade forces... it is formless, featureless depthless, scaleless, massless, surfaceless, and dimensionless... [where] there is nothing to see but our dependence on vision itself." Its physical presence is something that temporarily just happens to be so, arising and and passing – a storm, a spell of rain, a blurry wetness, a rising fog, a thicket of moisture – a transient occurrence that is of a nature so familiar, so immediately provocative towards the senses, experiences and imaginations that are the viewer's own, rather than something projected from the architectural object.

The French journal *L'architecture d'aujourd'hui* dedicated issue No. 354 in September-October 2004 to the investigation of the rising prominence and power of hyper-realistic digital renderings in the field of architectural design. The theme of the issue was "Le Pouvoir des Images, Documents et Fictions" ("*The Power of Images, Documents and Fictions*"). One article, "The Small Factory of Special Effects" by Denise Moreau, discussed works – artifices, synthesised images, digital renderings – by a company called Artefactory. Here a respected architectural journal is paying heed to a professional digital imaging company for its remarkable and indispensable role in supporting design development alongside famous architectural practices such as Jean Nouvel, Herzog & de Meuron, Bernard Tshumi and Renzo Piano. In 2003, Artefactory was responsible for producing all images in a solo show of Jean Nouvel's works at the Pompidou Centre in Paris, which astonished viewers. Moreau points out that Artefactory's output:

> *... cannot be summed up as simple visualisations of a hyper-defined model. They also bring into play pictorial effects that express lighting, texture effects and zones of haze that recreate depth of field. Pictorial and photo-real, Artefactory's work questions new relationships between architecture and imagery* (Moreau 2004:72)

Artefactory's renderings are successful in creating "a desire to see more, to enter an experience". Moreau goes on to say that these images "project viewers into a future already materialised, a state that already exists..." In other words, the design is pictorially materialised through the image production process of Artefactory. Herzog & de Meuron's project "Bird's Nest" Beijing Olympics Stadium 2008 is an example of a design process that exploits the power of pictorial materialisation made possible by Artefactory's



craft in digital imaging. Artefactory produced for H & de M the first effect drawing of the project: a sketch digital model and rendering of a bird's nest. This defining picture guided the entire course of design development.

Subsequent models and renderings were produced to elaborate upon the effect in the initial rendering. None of the lines in the final construction matched exactly, in a scientific sense, those in the initial digital model. The translation of measurement from one instance of rendering to another was not necessarily precise. But rather, the concern was in the reinforcement and amplification of the initial effect in each and every step of design progression. The initial rendering offered the design to the viewer as an experience: it is as much a process of materialisation as it is a process of realisation, ephemerally and concretely.

Another direction of development in the first decade of the C21st is the use of "scripting" which has been described as an algorithmic approach to design. The designer is simultaneously dealing with two windows on the computer screen: one containing the "code" in the form of an algorithm of vectorial forces, magnitudes, changes, etc.; and the other window showing the implication of coded instructions as a rendered "picture" or moving pictures, visualising the actual form and spatial entity. The language of codes provides the algorithmic instruction which does not determine a final outcome, but setts out a process of calculations which is dependent on variables, sequences, conditions and rules of interaction. The resulting visualisations are dependent on so many vectorial variables, but then, at the same time, the designer is responding to the rendered outcome and going back to make changes to codes to test other possible results. It is often the case that designers do not generate complex codes from scratch, but rely on communities of script-writing on the internet as sources of examples of innovative forms and effects achieved through a set sequence of codingwhich they copy into their own sequence of design coding, make desired modification and further combine with other codes. The searching and copying process of codes is reliant on rendered visualisation (vectorial elaboration dependent upon pictorial transmission) while the rendered visualisation is reliant on different combinations of coding process (rasterised reality-effect is implicated through vectorial variables). Eventually the design outcome would have multiple authors and contain a collaged set of pre-existing coding sequences. It is no longer possible to distinguish vectorial information from pictorial effect, nor the separation of algorithm and rendering in the design process.

Rendering differentials, manipulation of substance and effect, and the simultaneous code and picture, all epitomise the essential amalgamation of projective and pictorial in the age of the digital. This reaches the end of the projective, a speculation already posed by Evans in the 1990s as he reached his own conclusion of centuries of dominance of architecture as a Projective Cast:

> *This is why, from now onward, we must seek an alternative to this vision of the world as a project, which can so easily turn into a pointless glorification of an imagination victorious yet oblivious and inane* (Evans 2000:357).

Not to be considered as the opposite to the projective, "introjective" registers a visceral turn in the architectural design trajectory (Ragland-Sullivan 1986:144). The dissolution of the purely conceptual and the projective tabula rasa has been subverted by the provocation of vector-raster amalgamation, from the rendering of the curvilinear force-substance to the materialisation of pictorial effects, infused with the abundance of qualitative realities and references. Introjective design suggests a process working with what is already there: inherent qualities and forces, and transformations responding to immediate effects. Just like the way rendering differentials liberated the attribute of internal forces from the original object, the materialisation of effect made redundant the separation of atmospheric phenomenon from the original construction. Each vectorial form is rendered with its own parcel of emotive force; each visceral quality of reality is found with instructions of codes and numbers. No longer distinct, the projective and pictorial melted in the mechanism of "introjection", calling forth the arrival of an entirely new framework of design in the digital culture of C21st.

References

- Alberti, Leon Battista. (1988). *On the Art of Building in Ten Books.* trans. Rykwert, J., Leach, N., Tavernor, R. MIT Press, Cambridge, MA. (First presented in Italy to Pope Nicholas in 1450, First published in Italy in 1486).
- Carpo, M. (2001). *Architecture in the Age of Printing – Orality, Writing, Typography, and Printed Images in the History of Architectural Theory.* trans. Benson S. MIT Press, Cambridge, MA.
- Colomina, B. (2000). *Privacy and Publicity – Modern Architecture as Mass Media*. The MIT Press. (First published 1994).
- Corbusier, L. (1991). *Precisions on the Present State of Architecture and City Planning*. MIT Press, Cambridge, MA. (Originally published in French in 1930).
- Damisch, H. (2002). *A Theory of /Cloud/ - Toward a History of Painting.* Stanford University Press, Stanford, CA. (Originally published in French in 1972).
- Damisch, H. (2003). "Blotting Out Architecture? – A Fable in Seven Parts". trans. Rose, J. Log 1. Anyone Corporation, New York.
- Deleuze, G. (2006). *The Fold: Leibniz and the Baroque*. trans. Conley, T. Continuum, London and New York. (First published in French in 1988).
- Evans, R. (2000). *The Projective Cast: Architecture and Its Three Geometries.* MIT Press, Cambridge, MA. (First published 1995).
- Koolhaas, R. (2001). "Introduction", in *Great Leap Forward – Harvard Design School Project on the City*. ed. C. J. Chung, J. Inaba, R. Koolhaas, S. T. Leong. Taschen, Köln.
- Pfiffner, P. (2004). *Inside the Publishing Revolution* – The Adobe Story. Peachpit Press, California.
- Richter, J. P. ed. (1939). *The Literary Works of Leonardo da Vinci*. Vol I. Oxford University Press, Oxford.
- Teyssot G. (2000). "Baroque Topographies". *Assemblage* 41. MIT Press, Cambridge, MA.
- Lynn G. (1999). *Animate Form*. Princeton Architectural Press, New York.
- Leonardo da Vinci (2008). *Notebooks*. Selected by Richter, I. A. edited by Wells, T. Oxford University Press, Oxford. (First published 1952)
- Moreau, D. (2004). "La petite fabrique d'effets spéciaux : Artefactory au générique". *L'architecture d'aujourd'hui* 354.
- Ragland-Sullivan, E. (1986). *Jacques Lacan and the Philosophy of Psychoanalysis*. Routledge, London.
- Thomine-Berrada, A. (2008). "Pictorial versus Intellectual Representation", in *Perspective, Projections and Design* - Technologies of Architectural Representation. ed. Carpo, M. and Lemerle, F. Routledge, London.
- Wigley, M. (1998). "The Architecture of Atmosphere". *Daidalos* 68.

Doreen Bernath

Doreen Bernath completed her PhD at the Architectural Association London with the doctoral studies scholarship from the Royal Institute of British Architects. The thesis was shortlisted for the RIBA President's Outstanding Dissertation award 2011. She obtained MA and BA in architecture from the University of Cambridge. This was followed by several years of professional practice in London, Shanghai and Taiwan. Her research interest focuses on the visual culture of architectural production, critical history of art and architecture, media theories, transcultural studies between English and Chinese contexts, and probing contemporary tendencies in the digital culture. Her articles have appeared in Time + Architecture magazine in China, Dialogue magazine in Taiwan, and Research Journal of the Asia Centre at the London School of Economics. She was an editor of Scroope 13, the architectural journal at the University of Cambridge. She taught at the University of Nottingham,University of Plymouth, and directed summer schools at the University of Costa Rica and University of Detmold in Germany. Currently she teaches at the Architectural Association, Bartlett School of Architecture UCL and Leeds Met School of Architecture.

ESTA PUBLICACION FORMA PARTE DE:
THIS ARTICLE IS PART OF:

REVISTA**ARQUIS**

VER EL RESTO DE LA EDICION

VER OTRAS EDICIONES