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Architectural Objectiles

– Architecture, form, meaning and experience in the digital era.

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Abstract

The ongoing change of technological paradigm has great consequences for the production of architecture. We are moving from the mechanical to the digital, and also from “mass-production” to “mass-customisation”. New technology make long series of identical elements obsolete, industrially produced components can be unique, optimal in the construction. Other possibilities for different architectural expressions open, and for the *tectonic* aspects of architecture.

Digitally governed production could foster new modes of meaning creation. New conceptions and definitions of objects are emerging with parametric design. Non-standard production and culture could change our perception to more of an organic extension of human intelligence.

This paper discusses, with architectural examples from Kas Oosterhuis and Lars Spuybroek, the consequences of these technological and conceptual changes for architecture. Will the new technological paradigm foster a closer relation to human experience? Are there new possible relations to “body” and perception for architecture?

New tools – new perceptual experiences?

The world and our conceptions of it transform with technologies used for producing the objects surrounding us in the world. We are witnessing a change of technological paradigm with great consequences for the production of architecture. We are in many ways moving from the mechanical to the digital, and also from “mass-production” to “mass-customisation”. Architects have received new tools to conceptualise, imagine as well as realise our built environment.

Non-Euclidean, experimental architecture are today to be seen and built in many places around the world, but are in many ways caught in the prevailing spatial politics of late capitalism, where corporations and cities support an architecture producing icons. Here the visual is, as it has been for long time through Western metaphysics to modernism, still elevated over the haptic; the optical is in the centre of our experience and representation of the world, and thereby dominates other senses.¹ Henrietta Bier and Douglas Spencer have argued that the possibilities of experiential and social transformation implicit in non-Euclidian architecture and non-Cartesian geometries are negated by the appropriation of a purely visual style by many architects. Existing spatial relations and the regimes in which these parcel and alienate human experience remain intact because the relationship between the human and the architectural remains one of a

consumer and “spectacle”. “Supposedly non-Cartesian geometries and non-standard architectures are caught in some very Cartesian and very standard ways of operating in the world.”ⁱⁱⁱ

There are generative potentials in digitally enabled and non-standard architecture that may be carried over to corporeal and social encounters that transcend the act of mere signification – or one might say, that avoid the production of the *scenographic*, to use the terms of Kenneth Frampton.ⁱⁱⁱ But to achieve this, some sort of relay between architecture and the body need to come into play, a type of encounter be staged that visually-centred perception and experience implicitly preclude.

Non-standard architecture can challenge the processes of reproducing standardised identities and experiences of space – which the repetitive movements through standardised orthogonal spaces play part in – by foregrounding the perceptual activity of seeking out new sensorimotor schemas on the fly. This has larger implications for the social experience and politics of space, and cannot be seen as a pure semiotic novelty. There are potentials in digital architecture to resonate with the social and cognitive practices of human bodies, “to produce new spatial experiences that cut through the separation of perception from action, and point to the possibility of something more than the visual consumption of representational space – the possibility for invention, and reinvention between architectures and bodies”.^{iv}

Are we today actually witnessing a development of a new kind of “tectonic” with expressive potentials of construction through advanced geometry and technical possibilities, new digital and material technologies that might not be alienating but rather carrying potentials for a “critical architecture” of experiences? Many architects and thinkers criticising the consequences of global modernisation have been influenced by phenomenology to find new (or return to old) paths for architecture.^v One might ask if the digital tools in architecture, contrary to what one might expect, actually give new possibilities in line with the intentions of that critique. Will the new technological paradigm foster a closer relation to human experience? Are there new possible relations to “body” and perception for architecture? I will in the next pages of this paper try to discuss these issues.

Tectonics and Phenomenology

The new technological tools have increasingly led to new and closer collaborations between architects and engineers. We can see new architectural expressions drawing from actual forces in the structure, with a great understanding of construction and how to make it efficient. But these possibilities are not seen by everyone. Neil Leach has stressed that the architectural culture of today is still dominated in certain areas by a broadly Heideggerian outlook, a culture that remains largely critical of technology in general, and reluctant to embrace digital technology in particular.^{vi}

When phenomenology was introduced in the architectural discussion it was mainly as an instrument for critique of the modern technology. The essence of the tectonic in architecture was in this context sought after, but it was to some extent formulated as a *defensive* concept in relation to the machine age, where the reference to tradition was to be preserved. This led to a discussion often with remarkable culture conservative overtones, and the distinct normative features that the discussion about the tectonic has had remain until today.^{vii}

The Swedish philosopher Sven-Olov Wallenstein asks whether this is in the thought structures of phenomenology itself, or if it is due to a specific time-bound reading.^{viii} Wallenstein notes that

many interpreters of Heidegger have wanted to see an unmistakable proximity to a romantically tinted critique of technological modernity, but he notes that there is also an essential *distance* from such a critique that needs to be accounted for. This aspect gets wholly lost if we interpret Heidegger's thought as merely a *critique* of technology, or as a romantic rejection of alienation or technicity.^{ix}

Heidegger's meditations on space and place can and have been interpreted in radically divergent ways in architectural theory. The interpretations done by Norberg-Schulz, Frampton and Cacciari all start from the sense of a "loss of place", but the conclusions they draw are radically different.^x The more radical standpoint of Cacciari is however not the most widespread among architectural theorists drawing from phenomenology.

According to Leach, the prevailing Heideggerian attitude towards technology needs to be challenged. The arguments that technology is the perpetual source of alienation clearly overlook the potential for human beings to absorb the novel and unusual within their symbolic framework. Leach argues for a need to adopt a more flexible, dynamic framework that takes into consideration the chameleon-like capacity for physical adaptation that is a fundamental aspect of being human.^{xi}

Drawing mainly from the concepts of appropriation and mimesis, Leach even gets close to some discussions by Merleau-Ponty, when he points out that we have to understand our engagement with technology as involving a moment of "proprioception",^{xii} that technology comes to operate as a form of "prosthesis" to the human body, that is appropriated in such a way that it becomes part of the motility of the body. Here design becomes an important mechanism for "making people feel at one with their world", relating both to the aspects of aesthetically pleasing pieces of technology, and to the user interface and functionality. "Far from engendering alienation, well-designed technology has the capacity to *overcome* alienation."^{xiii}

The contemporary object

The French architect Bernard Cache was one of the first discussing in depth the implications of digital technology on the design and production of architecture.^{xiv} He states that early digital techniques were based on and imitated the traditional way of designing stemming from mechanical engineering and building, where pieces are designed as combinations of simple elements that can be drawn by ruler and compass. More complex contours of forms, as in automobile and aeronautical industry, were not actually calculated but subject to adjustment procedures where approximated curves, Béziers and Splines, are drawn from points positioned by hand.

In newer generations of digital design software objects are no longer designed but calculated, and Cache delineates two great possibilities by the use of parametric functions. First, it involves a changed mode of conception that allows complex forms to be designed that would be difficult to represent by traditional drawing methods. Second, these parametric systems lay the foundation for a non-standard mode of production, where the modification of calculation parameters allows the manufacture of a different shape for each object in the same series. "Thus unique objects are produced industrially. We will call variable objects created from surfaces 'subjectiles', and variable objects created from volumes 'objectiles'."^{xv}

Even though the first years of experimentation with digital techniques within architecture in many ways focused on aesthetics and generation of form, there are strong tendencies in architectural

conceptions based of parametric design to look more to functionality than isolated form. The use of parametric design makes it possible to contextualise the architectural object and make it adjustable and variable to the situations in where it shall function. Gilles Deleuze has written that in mathematics that assumes variation as its objective, the notion of function tends to be stronger: “The goal is no longer defined by an essential form, but reaches a pure functionality, as if declining a family of curves, framed by parameters, inseparable from a series of possible declensions or from a surface of variable curvature that it is itself describing.” Deleuze then, with reference to Cache, calls this new object *objectile*.^{xvi}

Deleuze underlines that this is a very modern conception of the technological object. This conception refers neither to the early industrial era nor to the idea of the standard that upheld a semblance of essence and imposed a law of constancy – where the object is produced by the masses for the masses (mass-production). It rather refers to our current state of things, where fluctuation of the norm replaces the permanence of a law. Here the object takes a place in a continuum by variation in a mode of production where identically stamped forms are replaced by industrial automation or digitally governed serial machines (mass-customisation). This new status of the object does, according to Deleuze, no longer refer its condition to a spatial mold – to a fixed relation of form-matter – but to a temporal modulation that implies both a continuous variation of matter as a continuous development of form. This is not only a temporal conception of the object but also a conception of qualitative modulations. “The object here is manneristic, not essentializing: it becomes an event.”^{xvii}

Let us now turn to how an algorithmic world of digitally controlled production, and its demand for other abilities of pattern recognition, might influence the design and experience of architecture, and the construction of architectural meaning.

An algorithmic world – of mass-customisation

The shift in architecture to more complex forms is not mainly due to architectural fashion, but a direct outcome of the digital design tools. Buildings that once were materialized drawings are now, increasingly, materialized digital information realised with digital tools and machines through the whole process from conceptualisation to production and assembly.^{xviii}

The forms produced by mechanical technologies are fixed, stable and solid, while those produced by electronic technologies are evanescent and variable. These digitally produced forms change and vary continuously – sometimes by choice and sometimes by chance. Mario Carpo shows how the difference between forms of the mechanical universe and forms of the digital universe is inherent in the two technologies: the mechanical world produces objects; the electronic world produces sequences of numbers, which in turn generate the object.^{xix} Today, no end product of any digital process is final, it is only an occasional product of an algorithmic process that can generate many different ones deliberately or at random. These unpredictable mutations have become a creative stimulus for some, a working tool for others and a nuisance for many.

Industrial-era machinery typically achieved efficiency through repetition, mass-production and economies of scale. In the digital era, numerically controlled machines have allowed similar efficiency with *non-repetitive* operations. Digitally governed industrial production is not dependent on the long series of identical products. A machine that only follows digital instructions does not care if it does identical production stages every time or if they are completely different. Operating systems that make the variation manageable are crucial, and an

algorithm is here a series of instructions or steps to be taken to solve a formalised problem, described in words, mathematical symbols or flow diagrams. The advantage of algorithmical methods of problem solving is that problems easily can be treated by computers. The algorithm is like an underlying pattern of a calculating process.

In a digital production process one algorithm alone can generate an infinite number of mathematical functions as well as various forms and surfaces, which all share this invisible originating algorithm. Every product in a digitally directed production process can be made unique, which makes possible serial production of series where every element in its form is different from the others – contrary to mechanical production where serial production imply repetition of identical elements. This kind of digital production is usually called “mass-customisation” instead of “mass-production” – or in architecture “non-standard” especially after the exhibition with that name in Centre Pompidou in Paris 2003.

Even if many experiments have been with organic and folded forms there is nothing that says that “non-standard” architecture could not be orthogonal or have any form what so ever. “Non-standard” is not to be considered a form-principle, according to Carpo; it does not relate to forms but to a mode of production.^{xx} Mass-customisation can include all possible products along the production lines of mass-production. By setting all parameters to the same value we can easily achieve the same as mass-production. But the other way round is impossible; mass-customisation includes mass-production, while mass-production does not include mass-customisation.^{xxi}

Mainstream modernist architecture, based on standardised components as well as standardised spatial relationships, radically reduced time and cost. But the process provided very little opportunity to adapt buildings sensitively to local culture, site and climatic conditions. Today the industrial foundations of modernism and early twentieth century have started to dissolve. New technologies and industrial logics make it possible for efficient, industrialised construction that can be more responsive and adapt to local conditions and efficiently handle complex structures. Standardisation and repetition are no longer necessary to receive better products to lower cost and to be able to keep a constant quality.

The modernist logic of the standard, its economic, technological and ethical assumptions is already obsolete, according to Carpo. And even worse, he continuous, if the old logic is applied to the current technological environment, it can lead to misguided decisions.^{xxii} Elements previously over-dimensioned to get economically beneficial sizes of the series, can now be produced optimally and following actual lines of forces in the construction, which opens other possibilities for different architectural and structural expressions. Consequently there might be new possibilities for interesting development of the *tectonic* aspects of architecture.

Digital production, based on transmission of invisible algorithms instead of reproduction of visual forms, will probably lead to changes in the whole visual culture of today. This might be seen as a revolution, but according to Carpo historically nothing new. Before modern standardisation of mechanical reproduction of images, humans lived for centuries in an algorithmic and normative world, not a visual and repetitive. One example is the orders of Alberti:

“Alberti's orders are chiefly a normative definition and a series of compositional, morphological and proportional rules – in today's terminology, an algorithm. The resulting visible form remained, to some extent, undefined, since the same norms can determine partially different architectural forms: in Deleuze's terms, one *objectile* in many objects; in Aristotelian terms (with

which Alberti would have been more familiar) one form in many events, or different species of the same genius.”^{xxiii}

Carpo shows that in the beginning of the early-modern age it was algorithmic and generative models – not the iterative and facsimile-like – that dominated the mode of production of architectural forms. It is not only the language of architectural orders that subsequently became standardized by the printed image; to a certain degree “it is the whole human ability to associate meanings and images (to identify, and thereby to confer meaning on non-alphabetic signs) that was standardized”.^{xxiv}

It is possible that the continuous variations of digital production will re-establish an algorithmic world, in which we will have to learn to see similarities, and reacquire some basic skills in “pattern recognition”. The processes of pattern recognition will probably have the same importance in a digital culture that they had in the pre-mechanical world, Carpo argues, which will also change our perception. “To a certain degree, perception will become once more what it always was, with the exception of a few centuries of typographical intermission: not a mechanical operation, but an organic extension of human intelligence.”^{xxv}

Motor geometries

Lars Spuybroek actively explores the possibilities of computers in design processes and the design of buildings. He sees the computer as a very powerful conceptual device, which is still a very instrumental machine through its possibility to synthesise in new ways perception and action as well as construction.^{xxvi}

Spuybroek is strongly influenced by the thinking of Maurice Merleau-Ponty, and has been occupied with questions concerning action and perception in architecture. Spuybroek describes our conceptions of our bodies as continuously expanding in a complex interaction with our environment. Questions of posture, perception and activity are architectural questions, and he names this relationship “motor geometry”, the abstract movement in the geometry of building, that relates directly to real movement of the body.^{xxvii} Artefacts, technical products become integrated in the motor system of the body. That is why we i.e. do not experience the car as just an instrument we are sitting in but something we become a part of when we drive. Movement and action are parts of the body; space is the haptic potential, the haptic sphere of action.^{xxviii} He argues that the continuity of action and perception can happen only in a body where perception and movement form a system which varies as a whole, through a body-schema or body-image. This system is constantly fed by movements and actions. Our body-image allows us to extend our actions into space.^{xxix}

Spuybroek seems to find objects and buildings like prosthesis working like vehicles adding movement to the body that adds a new repertoire of action. Here the body creates a haptic field centred upon itself, in which every outer event becomes related to this bodily network of virtual movements, the world connected to the millions of movements of the experiencing body, and becoming actualised in form and action.^{xxx}

The influences from Merleau-Ponty are both explicit and implicit,^{xxxi} and Spuybroek adds interesting dimensions and aspects to contemporary conceptions of architecture from phenomenology that is of another kind than the architecture most connected to the philosophy of phenomenology. Spuybroek considers architecture, following the notions of body-schema, as fundamentally plastic, topological and continuous, where the continuity between movement and

image is feeding action into perception and vice versa. The material construction of architecture is important to him, since it is what connects the horizontal act of movement with the vertical image of perception,^{xxxii} and today new possibilities to explore this relation appear.

Heavily influenced by the form-finding processes of the architect-engineer Frei Otto – with inspiration from nature and practical experimentation – Spuybroek's projects are despite their complexity based on factual construction, on transformational principles where the consolidation or stabilisation of the structure is a self-supporting, self-engineering aspect of the system. It is not the mere image of architecture that is explored, but the use of new tools in the actual construction of space. Strongly connected to the manufacturing process and structural principles new tectonic possibilities emerge as well as experiences of architecture.

The water pavilion H2Oexpo, in Neltje Jans, 1997, is an exhibition building not intended to “contain” an exhibition in a regular way. It differs from the classical museum, where seeing and moving are distinct, in that the images and sounds that emerge depends on the activities of the visitors, while, at the same time, the movements of the visitors depends on the constantly changing environment of running water, smells, lights, sounds. Besides being an advanced technical installation generating the changing atmospheres of the rooms, the construction is in itself a topological structure with continuously changing inclinations of floors, walls and ceiling that blends into each other. There are no windows to the outside showing the horizon, which makes the experience of space a very bodily experience, where you have to rely on you own motor system to balance and move around.

When architectural elements are connected through geometrical continuity a number of unexpected social effects also emerge, something seen in the pavilion and further explored in later projects like the office for V2_Lab in Rotterdam 1998. Here the space is designed to facilitate ordinary office functions in more distinct and determined spaces, but also to trigger new situations and behaviours in areas less formally determined with folding floors and curving, transparent textiles. The geometric “vagueness” in some spaces has shown a special potential, where active meetings can be staged or more relaxed conversations take place, all intensifying the working relations.^{xxxiii}

The question of how to involve action in perception was thoroughly addressed in the design of the exhibition wetGRID in Nates 2000. Here 250 paintings and drawings where to be arranged considering the theme of passive recording and active hallucination. Spuybroek's office NOX designed an amorphous body housing the paintings in the atrium of the museum. Here he further explored the concept of proprioception, of a body relying on its own internal balancing system instead of being kept upright by guidance of an architecture of vertical elements – posture as an emergent property produced by an interaction of architecture and body.^{xxxiv} The paintings were hung on the complex structure, on different heights on the walls, tilting in a manifold of directions. The visitor's body is actively involved in seeing the exhibited works; to see, one has to act, by tilting your neck, bend your knees or arch your back, adding dimensions to the experience of space and art.

Swarm architecture and hyperbodies

For Kas Oosterhuis and the office ONL computers and information technology has lead to radical changes in conceptions of the role of the architect, the process of design and the concrete buildings and architectural objects. Building parts are today potential senders and receivers of

information in real time, they can exchange and treat data that constantly can generate new or changing configurations. Today buildings can, like modern cars, have a multitude of processors sensing, calculating and reacting to external factors. Just like cars can show a responsive behaviour, responsive buildings can react to changing conditions.^{xxxv}

He talks about a “swarm architecture” that is developed in real-time considering the process of design and construction as well as the way the building functions, where all building elements act as intelligent actors, as active members in a swarm, conscious of their environment, constantly calculating and reacting.

Traditional vernacular building is based on very direct processes of design and execution, where no intermediate phases of working drawings, elaborated detail drawings are needed. The buildings materialise from a set of simple rules where the specific building as well as the details adjust to local constraints producing a coherent whole with lots of variation. Oosterhuis argues that we today are able to establish similar processes relying on digital techniques putting design and production closer. With networks of machines communicating directly we can produce an endless variety of building elements, visually rich and complex, but still based on simple rules. This process of mass-customisation is based on file-to-factory production methods, in which everything is different in absolute size and positioning. The variety is not due to human non-accuracy, but thanks to computational processing of diversity.^{xxxvi}

Besides building usual static architecture, Oosterhuis experiments with information driven architecture that forms “building bodies” which show real-time behaviour.^{xxxvii} These “building bodies” – or hyperbodies – are complex wholes, a complexly integrated system of custom made building elements formed by the forces they are exposed to.

By using inflatable building elements, intricate constructions with pneumatic cylinders and moving parts, screens, fibre optics, loudspeakers etc., buildings can be created that change form as well as atmosphere through parameters as user actions and weather conditions. An interactive architecture of “hyperbodies”, like the installation “MUSCLE”, Paris, 2004 or iWeb pavilion, Delft, 2007, is aiming at a two-way communication between human beings and the environment they are occupying, between building elements and users.

The work of ONL is highly technological, following the rationale of contemporary industrial thinking, and the actual function of the building is of main concern in its interaction with men and matter on the specific site. Oosterhuis is trying to balance the bottom-up and top-down aspects of design – buildings as systems communicating with local conditions of use, climate and specific environment, as well as with more global, urban, symbolic and cultural aspects. But the top-down concepts applied are never traditional or conventional symbols. The connection to the surroundings and the legitimization of the building on the site can never be done by returning to history or established norms. He argues that many urbanists seem to develop a xenophobic fear of alien bodies thinking that buildings grow from the ground. Nothing can be less true, they come from elsewhere; all concepts and materials are transported from remote places to be assembled on the specific spot. Oosterhuis rather sees the potential in bringing something unforeseen to a place, something never experienced before, that are forcing us to think differently and put us in another state of consciousness. And this is exactly what he thinks designs like those of ONL’s can bring about in historic settings.^{xxxviii}

There are other strong, practical arguments for developing swarm-like architecture. Building components like columns, trusses, walls, floors can become actuators cooperating with each other to perform and respond to changes in the physical environment. Such adaptive constructs could react in real time to resist local forces acting on the structure, and may be used to stabilise and make buildings and bridges stronger and more efficient than traditional constructs.^{xxxix} Non-standard architecture not only widens the possible experiences of built structures for clients and users, but can also open up a territory of potential profitable economic and structural efficiency.

The Acoustic Barrier and Hessing Cockpit in Utrecht (2005) was designed by ONL from the two perspectives of an strict inner logic of a few parametric details – all based on the same algorithm but all unique in their adaptation to their position in the structure and its relation to the surroundings – and an external gesture. The external design gesture was made from the point of view of the car driver driving at 120 km/h on the highway along the barrier. Driving pass offer an experience of slow transformation, a dynamic but smooth, soft feeling infusing calmness. On the site you experience a very specific and in the landscape surprisingly well-fitted and expressive structure.

The design of this coherent complex of unique pieces of steel and glass was made possible by the parametric detail of Acoustic Barrier, that immediately connects the styling of the surface to the construction and manufacturing of it. “Architecture, construction and manufacturing are one, in much the same way as body, skin and hair are one.”^{xl} The integrated architectural, structural and production concept of Acoustic Barrier shows that – thanks to the direct connection between the design model and the manufacturing machines through scripting based on simple rules – a complex building can be an expressively and efficiently engineered product, within a regular budget.

It is a building with the purposes of giving distinct aesthetic experiences, contain business premises and function as a acoustic barrier to the surrounding housing area. The building design has tectonic qualities in its effective, but strangely undulating, structure in a very contemporary way, it is grounded in and has a clear relation to its context by the way it adjust to it and function, but it is at the same time a strange object, something alien invoking new thoughts. These new architectures emerging from new kinds of industrial production and design tools require new thinking and conceptions of architecture both from the perspective of the designer and the person experiencing the built environment.

Perception, body and experience in the digital age

Returning to the initial questions, I hope my argument is clear that we today actually are witnessing a development that through new technical possibilities and advanced geometry could promote a new kind of tectonic. The new digital and material technologies might not at all be alienating, but rather have capacity to overcome alienation and through perceptual experiences make people feel at one with the contemporary world.

The digital tools in architecture, could actually give new possibilities in line with the intentions of the earlier critique of technology inspired from phenomenology. We could exploit the changed processes of signification and representation, and resist the “meaningless” through new modes of pattern recognition. But there are still a lot to do, on the conceptual as well as practical levels.

New technological capabilities are not always wisely used, and much of the potential of digitally enabled variety has been deployed for sensational effects. But from the work presented here, we

might agree with Mitchell that, it is obvious that thoughtful architects see beyond the seduction of the surprising and are finding new ways of responding to the demands of the complex conditions of the situations they engage in.^{xli} There might be possibilities for “an authentic architecture of the digital era” to emerge, where perception and action, the expressive, symbolical, functional and technical aspects of construction intertwine in new ways. There are ways to further the tectonic in architecture, by developing a conscious and open view on the new technological and industrial paradigm. This even could set the representational and ontological aspects of tectonic form in new relations, counteracting any opposition between detailing and the overall image.^{xlii} A critical consciousness of contemporary technology is necessary to also be able to utilise the potentials for other politics of space, as well as human and social experiences in architecture.

Biography

Fredrik Nilsson, architect SAR/MSA, PhD, architectural researcher and critic. Nilsson is currently guest researcher at Chalmers School of Architecture, and is working at the architectural office White Arkitekter, Göteborg, Sweden. He has taught and lectured at several of the Schools for Architecture and Design in the Nordic countries, and written on especially contemporary architecture, architectural theory and the relation to philosophy. Among his published books are *Ur sprickorna i spegeln – Dekonstruktion, Derrida och arkitektur* (Stockholm: Byggförlaget, 1996), *Konstruerandet av verkligheter. Gilles Deleuze, tänkande och arkitektur* (Göteborg: Chalmers, 2002), *Om arkitektur*, co-editor with Claes Caldenby (Stockholm: Byggförlaget, 2002), *Utforskande arkitektur*, co-editor with Sten Gromark (Stockholm: Axl Books, 2006), and he frequently publishes articles, architectural criticism and reviews of books in professional journals and daily press.

ⁱFor a discussion on this see i.e. David Michael Levin (Ed.), *Modernity and the Hegemony of Vision* (Berkeley: University of California Press, 1993).

ⁱⁱHenrietta Bier & Douglas Spencer, “The Body in Digital Architecture - From Representation to (Re)Invention”, in Patrick Healy & Gerhard Bruyns (Eds.) *De-/signing the Urban. Technogenesis and the urban image* (Rotterdam: 010 Publishers, 2006), p 392.

ⁱⁱⁱSee Kenneth Frampton, “Towards a Critical Regionalism: Six Points for an Architecture of Resistance”, in Hal Foster (Ed.) *The Anti-Aesthetic. Essays on Postmodern Culture* (Port Townsend: Bay Press, 1983).

^{iv}Bier & Spencer, “The Body in Digital Architecture - From Representation to (Re)Invention”, p 397.

^vSee Frampton, “Towards a Critical Regionalism”; Juhani Pallasmaa, *The Eyes of the Skin. Architecture and the Senses* (Chichester: Wiley-Academy, 2005); Steven Holl, Juhani Pallasmaa & Alberto Pérez-Gómez, *Questions of Perception. Phenomenology of Architecture* (Tokyo: a+u Publishing Co, 1994).

^{vi}Neil Leach, “Forget Heidegger”, in Neil Leach (Ed.) *Designing for a Digital World* (Chichester: Wiley-Academy, 2002), p 22.

^{vii}Sven-Olov Wallenstein, *Den moderna arkitekturens filosofier* (Stockholm: AlfabetaAnamma, 2004), pp 21-22.

^{viii}Wallenstein, *Den moderna arkitekturens filosofier*, p 34.

^{ix}Sven-Olov Wallenstein, “Towards the Essence of Technology. Heidegger and the Case of Architecture”, in *Essays, Lectures* (Stockholm: Axl Books, 2007) pp 324-326.

^xWallenstein, “Towards the Essence of Technology”, pp 343-344.

^{xi}Leach, “Forget Heidegger”, p 24.

- ^{xii} *Proprioception*: “from Latin proprius, meaning “one’s own” and perception) is the sense of the relative position of neighbouring parts of the body. Unlike the six *exteroception* senses (sight, taste, smell, touch, hearing, and balance) by which we perceive the outside world, proprioception is an *interoception* sense that provides feedback solely on the status of the body internally. It is the sense that indicates whether the body is moving with required effort, as well as where the various parts of the body are located in relation to each other. Kinesthesia is another term that is often used interchangeably with proprioception.”
<http://en.wikipedia.org/wiki/Proprioception>, 2007-03-17.
- ^{xiii} Leach, “Forget Heidegger”, p 29.
- ^{xiv} Bernard Cache, *Earth Moves. The Furnishing of Territories* (1995), the unpublished French manuscript *Terre meuble* was written 1983.
- ^{xv} Bernard Cache, *Earth Moves. The Furnishing of Territories* (Cambridge, Mass: The MIT Press, 1995), p 88.
- ^{xvi} Gilles Deleuze, *The Fold. Leibniz and the Baroque* (Minneapolis: University of Minnesota Press, 1993), pp 18-19.
- ^{xvii} Deleuze, *The Fold*, p 19.
- ^{xviii} See William J. Mitchell, “Constructing an Authentic Architecture of the Digital Era”, in Georg Flachbart & Peter Weibel (Eds.) *Disappearing Architecture* (Basel: Birkhäuser, 2005), p 82.
- ^{xix} Mario Carpo, “Pattern Recognition”, in Nanni Baltzer & Kurt W Forster (Eds.) *Metamorph. Focus* (Venezia: Marsilio Editore, 2004), p 45.
- ^{xx} *Ibid.*, p 55.
- ^{xxi} Kas Oosterhuis, “A New Kind of Building”, in Georg Flachbart & Peter Weibel (Eds.) *Disappearing Architecture* (Basel: Birkhäuser, 2005), p 93.
- ^{xxii} Carpo, “Pattern Recognition”, p 48.
- ^{xxiii} *Ibid.*, p 52.
- ^{xxiv} *Ibid.*, p 52; see also Mario Carpo, *Architecture in the Age of Printing* (Cambridge, Mass: The MIT Press, 2001).
- ^{xxv} Carpo, “Pattern Recognition”, p 56.
- ^{xxvi} Lars Spuybroek, “wetGRID: the soft machine of vision”, in Neil Leach (Ed.) *Designing for a Digital World* (Chichester: Wiley-Academy, 2002), p 98-100.
- ^{xxvii} Lars Spuybroek, *NOX. Machining Architecture* (London: Thames & Hudson, 2004), p 36.
- ^{xxviii} Spuybroek, “wetGRID: the soft machine of vision”, p 93 and Lars Spuybroek, “Motor Geometry”, in Stephen Perrella (Ed.) *Hypersurface Architecture. Architectural Design Profile* (Chichester: John Wiley & Sons, 1998), p 49.
- ^{xxix} Spuybroek, *NOX. Machining Architecture*, p 6.
- ^{xxx} Spuybroek, “Motor Geometry”, p 49; Lars Spuybroek, “The Structure of Experience”, in Cynthia C. Davidson (Ed.) *Anymore* (Cambridge, Mass: The MIT Press, 2000), p 167.
- ^{xxxi} See Maurice Merleau-Ponty, *Phenomenology of Perception* (London: Routledge, 1962), especially Part one: The body.
- ^{xxxii} Spuybroek, *NOX. Machining Architecture*, p 7.
- ^{xxxiii} *Ibid.*, p 95; Spuybroek, “The Structure of Experience”, pp 171-172.
- ^{xxxiv} Spuybroek, *NOX. Machining Architecture*, p 139.
- ^{xxxv} Kas Oosterhuis, *Hyperbodies. Towards an E-motive architecture* (Basel: Birkhäuser, 2003), p 5, 55.
- ^{xxxvi} Oosterhuis, “A New Kind of Building”, p 92.
- ^{xxxvii} Oosterhuis, *Hyperbodies*, p 33.
- ^{xxxviii} Kas Oosterhuis, “Swarm Architecture II”, in Kas Oosterhuis & Lukas Feireiss (Eds.) *Game Set and Match. On Computer Games, Advanced Geometries, and Digital Technologies* (Rotterdam: episode publishers, 2006), pp 26-27.
- ^{xxxix} Oosterhuis, “Swarm Architecture II”, p 22-23.
- ^{xl} Oosterhuis, “A New Kind of Building”, p 100.
- ^{xli} Mitchell, “Constructing an Authentic Architecture of the Digital Era”, p 89.

^{xlii}See Kenneth Frampton, *Studies in Tectonic Culture* (Cambridge, Mass: The MIT Press, 1995), p 16, 26.