A Motion as a Modern Way of expressing Architecture

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“[...] When I look outside the door what do I see? An airplane flying over, a car passing by. Everything is moving. That is our environment. Architecture should deal with that.[...]
Frank Gehry

There are many words written about the motion in architecture. (Giedion, Ferstegen, Jormakka, Lynn). They try to describe, classify, separate or represent it. This work presents motion as one of the leading factors of contemporary ways of expression in architecture. It will examine different examples of architectural motion, then make a hypothesis, that one of the possible reasons of expressing movement in architecture is the usage of new generation of modern CAD/3D-animation software, like 3DStudio Max, Lightwave, Maya, Catia, Rhino, or CINEMA 4D. Because of availability only chosen features and tools of CINEMA 4D will be described further.

Motion can be expressed in architecture in two ways: by the procession or by superimposition. [Lynn,1998] In processional models of time, architecture is the immobile frame through which motion passes. It is based on static frames and has fixed relationships between functional program and user. The elimination of force and motion from form is the basis of recent alternatives (e.g. sequential model). Through the multiplication and sequencing of static frames it introduces the idea of “dynamic” architecture as multiply framed.

An alternate model of time and motion resists the separation of form from its animating forces. Form is perceived in a space of virtual movement and force rather than within an ideal equilibrium space. Instead of a fixed prototype, flexible, mutable models are created, which are rather a potential of multiple variables (“performance envelope”). In result “architecture can be modeled not as a frame but as a mobile participant in dynamical flows.” [Lynn, 1998]

To do that, necessary is more than a shift in technology is necessary, but rather a shift in sensibility from reduction to combination, to compose time based, topological designs. Although the introduction of time and motion techniques into architecture affects visual qualities, it is inappropriate to understand technology in terms of style.

Sculpturing buildings – a frozen motion
Aaron Betsky writes: “It is no longer enough [...] to make forms that make
sculptural sense”. [Betsky, 2003] Nevertheless there is a distinct direction of making architectural designs twisted, squeezed, scattered, generally: deformed. [Pongratz, Perbellini,1999]
This attempt is visible not only today. Borromini has created a spiral lantern at the top of Sant Ivo's cupola in XVI century. That expressed a baroque dynamic and a research of freeing a form.

Erich Mendelsohn has created his Potsdamer Einstein Tower in response to new possibilities of reinforced concrete. It was a “contributing element of movement itself” [Jormakka,2002] In the 20-ies of XX century there were some devices expressing movement: inclined planes, acceleration of façade rhythm and aerodynamic curves. Those devices remained almost unchanged, but expanded due to a technology development: buildings animate themselves and interactively respond to user needs. What is more important: there is no longer a need to IMITATE a movement. it can be true.

Frank Gehry is the man, who created the most expressive architectonic sculptures of today. His Guggenheim Museum in Bilbao (Spain,1992) represents conjunction of stillness and motion, order and disorder. It attempts to capture „frozen motion“ and corresponds to the scientific pursuits of Ilya Prigogine, the chaos-theory physicist. Twisted solids were prepared with permanent usage of CNC-routers and aviation industry software.
Other Gehry creations confirm the similar attitude. Independently from the complex tools and design methods, his buildings express a motion, being at the same time very static and stable. The ways of expressions are: superimposition, twist and bend. A pencil was replaced by Catia and concrete by a steel ribs and metal cladding, but almost nothing has changed from the times of Mendelsohn.

A competition for a „Virtual House“ (1997) won by Foreign Office Architects represents different aspects of motion and ways of expression. The motion was captured using the flexible extruded ribbons, interweaving with each other and a virtual character of the space was stressed by the fact, that this design could be placed “anywhere”, and it was commissioned by “any corporation”. Still nothing animates itself.
The idea of building, depicting a frozen motion is present in the early houses design by Peter Eisenman. At the later designs he used more advanced techniques, like folding or seeking for a continuity between exterior and interior, expressed in the “in-between” state (like a liquid crystal). Further experiments and the evolution of this method brought Eisenman to superimposition of repetitions – in fact the Wexner Center represents a state of being “formless”. The basic tool used in his transformations is a diagram. Eisenman has created his own taxonomy, where a basic division is set between interiority, anteriority and exteriority. Within this boundaries are classified (and utilized in projects) conceptual and formal tools, like: extrusion, twisting, displacement, morphing, torquing, superimposition, nesting, repetition, scaling, rotation, folding, layering, voiding, decomposition, blurring and many more. [Eisenman, 2001]

Looking at the project of Staten Island Institute for Arts and sciences (2001, N.Y.) one can immediately recognize used diagrams as laminar flow combined with a superimposition, while in the earlier Max Reinhardt House (Berlin, 1992) is present twisting, rotation and torquing.

Figure 5: Max Reinhardt House- P. Eisenman
Transformations of described 3D-models are combining the real and virtual by simulating a building’s motion. This motion is captured as frozen and becomes a way of expression in itself. Another important feature of the examples above is the global character of 3D transformation. The rotation, lofting, extrusion, etc. affects the whole body of the building – the only decorative element is the expression of motion.

Apparently the chaotic, unbridled form of the designs above is similar to the baroque style because of its monumentality, curvature and simulation of not existing – whether it was a perspective illusion, or a motion and time-mutation.

What specific 3D/CAD tools enable expression of frozen motion? CINEMA 4D offers a few kinds of parametric modelling, capable of fast and interactive work. A first group of available deformations contains among others: bend, twist, bulge, taper, melt, wind, shear, wrap, etc. They are relatively old and simple.

Another type of deformation are of non-uniform rational B-splines (NURBS), already well explained and described. CINEMA 4D offers e.g.: HyperNURBS, SweepNURBS and BezierNURBS. Combined with direct point and surface edition (e.g. PLA) this type of modelling appears attractive, and creation of complex shapes and solids is relatively quick and easy.

**Animation and literal motion**

Traditionally the notion of animation is understood in many ways, which mostly mean a simulation of a movement. There is, however a different way of understanding animation, used in contemporary architecture, the virtual, and the real one: the change of parameters in time or “the act, process, or result of imparting life, interest, spirit, motion, or activity”. A distinct difference between animation and motion is made by Greg Lynn: “Where motion implies movement and action, animation suggests animalism, animism, evolution, growth, actuation, vitality and virtuality.”

Some contemporary experiments attempt to simulate the building motion not by capturing it, but rather enhancing, creating the interplay “user-building”. A dense information network, supported by sensors from one side and pneumatic engines, transform external impulses into building
responses. This causes buildings to be unstable, transitory – unlike architecture should be.

The dream of motion in architecture has been introduced almost 90 years ago – in 1919 Tatlin designed a Monument for the Third Internazionale, which was the kinetic structure, where a few platonic solids (cube, pyramid, cylinder) were rotating along a vertical axis at specific speed (1 rotation per year, per month or per day). The steel spiral of Tatlin tower was scheduled to be 400m high.

Many other kinetic structures was built since then and today that trend is still visible, although the motivation and the technical advance of movement differ.

Kas Oosterhuis' experiments with interactive architecture, like Trans-ports (2001) and E-motive house (2002) proves, that interactive, animated architecture becomes reality. They define possible direction of future research.

The first object “acts like a muscle”, connected to data (input-output devices) in real-time. It uses three main elements: electronic interior skin, pneumatic “muscles” and flexible exterior skin. Instead of being static, it is rather like a lean device, which relaxes or tightens upon different forces.

E-motive house is a weaving loom between a hard and a soft structure. The construction of the house and the furniture is programmable. Everything changes, except the kitchen-area and the sanitary. It is an interactive adaptive system.
Among many well-known interactive projects one might place as well Aegis Hyposurface (dECOi, 1999-2001), Tower of Winds (Toyo Ito, 1986) and Saltwater Pavillon (Kas Oosterhuis, 1997).

Motion in architecture can by understood literally. Kas Oosterhuis project for Graphisoft Slider (2002) is a set of programmable sliding volumes to be built on the river Danube in Budapest, which “not a single person will ever experience the same”. The main idea of this project was to retain two old concrete crane slider bars and establish a new mobile construction on the top of it. There are four main elements (oval cage, yellow glass box, cloud-shaped functional blobs and mediatube) moving independently in continuous, unpredictable motion. The object should “play” like an instrument, be alive, never static and programmable.

Permanent mutation is visible at urban scale too. Traditional city exists no longer, but it is replaced by a hypercity, where new shops grow up and replace the old, where old squares disappear and new perspectives arise within a months. This state of transformation is enhanced and supported by a network of information connections. A building, a city, an airport, a car, a human has become only a node, a vertex of a whole system, constantly moving.

What specific 3D/CAD tools enable experiments with interactivity and mutability? First: the ability to simulate by the computer all kinds of motion. Motion
of external sliders or blinds, door rotation, camera and light animation construct a virtual animated 3D model, which replaced laborious, expensive and inflexible mock-ups or cartoon animations. Even more challenging is an ability to simulate natural behaviour of 3D objects – the influence of gravity, impact of wind, spring stretching, billard bowls collision, a book falling onto a pillow, etc. A good example is Dynamics of rigid and soft bodies supported by CINEMA 4D or Pyrocluster tools offering a simulation of special effects, like fire, clouds, smoke or volcanos.

There are many other tools supporting animation experiments, like the modern interface (e.g. Sculptor, ETH Zurich) often derived from computer games or movie production software, which support motion overlaying and mixing, or even popular pneumatic actuators. All of them stress the importance of transition instead of duration.

Metaphor of motion

The most advanced ways of architectonic expression are transformations of different data-systems: sounds into light, words in diagrams, equations in movements, data into 3D forms and many more. These transformations consist of precise limitations, conditions and (mathematic) rules, fields of forces, algorithms (often genetic) and their pictorial layer is often perceived like generic, random forms. They are animated and variable but their impression is confusing as a snapshot or still frame.
Their common denominator is reinvention of time: from a static to dynamic perception, from balance to tension. That results in a specific motion - architecture becomes rather like a condition than a building per se, it shifts in time and due to many possible interpretations it becomes virtual.

To analyze the influence of invisible fields of forces on the real space and buildings, we may start from the MVRDV “Datascapes” (1999). They believe, that it is possible to identify for every area its “gravity field”, which means a set of apparently chaotic, hidden rules. These rules reveal themselves under special conditions: within certain limits or exceeding a threshold. They proved that hypothesis with many examples, like Ruhrgebiet, where accessibility demands caused a series of linear towns, or Berlin’s urban regulations, putting new buildings in tight districts, which caused growth and exploration of undergrounds, or Paris’ La Defense, where the 18-meter long fire-ladders caused Ziggurat-like shape of offices. “The datascapes are visual representations of the quantifiable forces that may influence the work an architect or even steer or regulate it.” (Lootsma B.) Let’s have a look at the architecture created using the representation of field of forces.

Relatively simple is the idea of blobs. The principle of blob is to give the simple sphere two zones: an influence and a deflection, which are interacting and pulling or fusing surfaces into collective meshes. One of the earliest examples of using blobs at the conceptual level is Korean Presbyterian Church (Greg Lynn, NY, 1995), where the “body” was calculated like the equilibrium state of fusing and growing nodes with assigned gravitational force.

Figure 11: Blobs, idea for Korean Presbyterian Church - G.Lynn]
because of two reasons. First - it’s shape is created by a literal visualization of motion flows of pedestrians, cars and buses across the site, and then - it is a transformation of numeric data in a 3D-form (two different systems).

![Figure 12: Port Authority Gateway - G.Lynn](image)

The whole range of Marcos Novak projects, oscillating on the edge of real and virtual are using the idea of transformation different data-systems. Liquid architecture (1993), Variable Data Forms, 1999) or Paracube (1997-8) use algorithmic variables, which represent channels with mapped external rule or limitation, either static or dynamic. They are never modified manually and often derive from a higher dimension geometrys. Novak introduced for his creations a notion “liquid”, which means complete but rigorous variability driven by data shifts in cyberspace. In his works motion is perceived rather like a variability and virtuality of form.

![Figure 13: Data driven forms- M.Novak](image)

Returning to the exemplifying software (CINEMA 4D) we find out specific tools used to simulate the effects described above.

The concept of particles can be realised using Thinking Particles. As the name indicates, they are intelligent, parametrically defined objects,
like emitters, attractors, deflectors, friction, gravity, wind, rotation and turbulence. Each of them has precisely defined constraints and conditions of life, for example: emitters are given lifetime, speed, birthrate and visibility, while gravity – acceleration and size. Inserted in the 3D-model and animated, they simulate a real wind or gravity. In this case all the object variables are defined in the dialog windows, without having to create any script.

Figure 14: Thinking Particles

Not only specially designed particles can be parametrically described. To every object (even a simplest one: a cube, box, etc.) can be assigned a tag precising its behaviour under certain conditions, like a motion constraint, scale imitation, etc. In other words, object properties can be bound and interact with each other.

For example Blobs can be created as Metaball objects, consisting of a few bowls with a radius and a strength given, while a target object is given a hull and a subdivision value.

Figure 15: Metaballs
But more complex and powerful possibilities of object interaction are available. Using a parametric (sometimes visual) interface, where certain expressions are subordinated to input-output nodes. It can be XPresso editor, where all the nodes and operators are defined by drag and drop technique.

or a more advanced COFFEE expressions, defined as a script in the text window.

Conclusions

Motion described above became a crucial way of architectonic expression, nevertheless it is literal, frozen or a metaphorical one. It transforms the principal rules of traditional architecture (“firmitas, utilitas, venustas”) and neglects the “stability” of architectural form.

Transforming a movement from a virtual 3D world to a real one results often in curvilinear forms. Such architecture will be soon affordable, because of the direct connection “file to factory” which redefines the economy of building production. Instead of mass-production it develops “mass-customization”.

Using a motion as a way of expression, demands from architects a narrow-band specialisation together with multidisciplinary knowledge.

The transformation of architecture itself and its way of expression is still running. In motion.
References

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Lootsma B. “Architecture in the second modernity” ArchiLab.Radical experiments in global architecture (ed. Frederic migairou,Marie Ange Braier); Thames&Hudson 2003 , p.23

Oosterhuis K. “Hyper Bodies.Towards an e-motive architecture”; Birkhauser 2003
Footnotes

1 New Perspectives Quarterly vol.21#1 Winter 2004, “From Shiva to Disney, Frozen motion”, http://www.digitalnpq.org/
2 Formalisation proposed by Sigfried Giedion where time is built into form as memory and Collin Rowe’s phenomenal transparency
4 Motion is present in many ways in digital techniques developed in the last decade, like computer animation, algorithms, parametric modeling, data fields, etc.
5 The same attitude is presented in Springtecture B, completed by Shuhei Endo in (2002., Biwa-cho, Schiga) and Degrezero – “Library for the information Age’
8 Any change of a parameter over time. Generally refers to a change in position of the video frame, moving the video over a background while it plays. www.digitalpostproduction.com/Htm/Features/DigitalVideoGlossary.htm
9 http://www.dictionary.com
10 Examples : Television Tower in East Berlin, Kuwait Pavilion for Sevilla World Expo.
11 http://www.oosterhuis.nl
12 http://www.festo.com
13 see also Kolatan Mac Donald Studio – “co-citation mapping” – 1994 – Yokohama Ocean liner Terminal
14 Genetic algorithms are inspired by Darwin’s theory of evolution. Problems are solved by an evolutionary process resulting in a best (fittest) solution (survivor) among a number of possible solutions.
15 It derives from special film effects and modeling tools used in Softimage and Wavefront, where blob ment the acronym for “binary large objects”. http://www.glform.com
16 together with Nonchi Wang - 1993
17 supported e.g. by IGES files