Architecture is Performance

Giorgos Artopoulos and Stanislav Roudavski

The complete "body" of the "mature" Parasite was "grown" as two shells, suspended in a stairwell space in the Museum of Modern Art in Prague. Four video projectors cast moving images through the cellular surfaces and onto the walls. People came into the light and cast shadows. In response to the visual rhythms, the Parasite "sung": this time quiet, now aggressive, never exactly the same.

The installation in the Museum of Modern Art was but a moment in the Parasite's life that extended through the interests of its "authors", through its painful formal birth as a virtual structure, towards its part-real, part-imagined coming-of-age as a dramatic eruption and further on towards inescapable disintegration and oblivion. Its story is still in progress. Its architecture is not of matter but of performance; it is forever becoming.

Design Process

The pavilion was designed to fit into a stairwell that connected the main exhibition hall located on the ground floor, the secondary entrance to the museum (that became the primary entrance during the evening events) and the performance/exhibition spaces of the lower level. The structural form of the pavilion consisted of two organically shaped, topologically cylindrical shells consisting of 1,510 unique cells and the interactive audio-visual system able to respond to the behaviour of the visitors.

The design process was in three phases. Firstly, dynamic simulation and time-based processes were used to produce two organic surfaces fitting into the stairwell space. Secondly, the computer-driven responsive audio-visual system was laid out in relationship to these surfaces. This system incorporated image-based computer vision and was able to create real-time audio and video compositions in reaction to peoples' movement through the space. Thirdly, the two organic surfaces produced during the first phase of the design process were materialized as building components. This materialisation was enabled by a technical framework for the procedural production of a built structure under a variety of situational constraints and in response to the performative requirements of the audio-visual system.

The spatial intervention in the form of a built structure was a significant part of the project. It intended to provide two kinds of impact. Firstly, the structure impinged on peoples' behaviour such as movement through space or visual access with the intention to engender new social encounters. Secondly, the structure in combination with projected images created a visual field that could inform the visitors, redirect their attention and involve their bodies in the making of the dynamic visual form. Plant-cell microscopy images, urban-texture photographs and dance movies were processed so that their pattern-based nature was made apparent. The visual field consisted of the pattern-based spatial structure, pattern-based video imagery and the participants' bodily movement through the space. While static after construction, the structure was intended as a procedural response to the given environment. Its responsive nature called for a modular, component-based arrangement able to conform to geometrically complex surfaces and flexibly adapt to the changes in local conditions (Fig. 1). These requirements led to the interest in honeycomb and similar structures.

Fig. 1. A fragment showing local curvature-dependant variations (photograph)

Previous experimental work (Kudless, 2005) explored the use of honeycomb structures for the construction of curvilinear geometry. One of the Parasite-project's goals was to see if the cell-based approach could be taken further with the use of non-periodic patterns capable of local change. The pattern adopted after preliminary research was a Voronoi diagram defined as "the partitioning of a plane with *n* points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other" (Weisstein, 2005).

During the design stage, several clusters of random points were generated along a set of construction surfaces defined to respond to the dimensions and performative characteristics of the location. Dynamically responsive three-dimensional curves were drawn through these points. Next, two periodic surfaces were lofted through the curves. Multiple dynamic fields were set, positioned and adjusted as the simulation was run through multiple iterations. When an acceptable intermediate shape was arrived at, an array of dynamic particles was distributed along the surfaces that were squeezed to fit into the stairwell. The distribution and form of the cells was arranged via more multiple iterations in response to further constraining conditions.

From this point, the task was to reach from the virtual to the real. The details were laid flat and prepared for manufacturing. The cell-walls were laser-cut and scored by computer-driven machines. The plastic skins were plotted and cut out. The components were then brought to the Museum galleries (Fig. 2) and the assembly work began. After many metamorphoses and temporary dwellings, the shells condensed into the patches that were left to occupy the exhibition spaces.

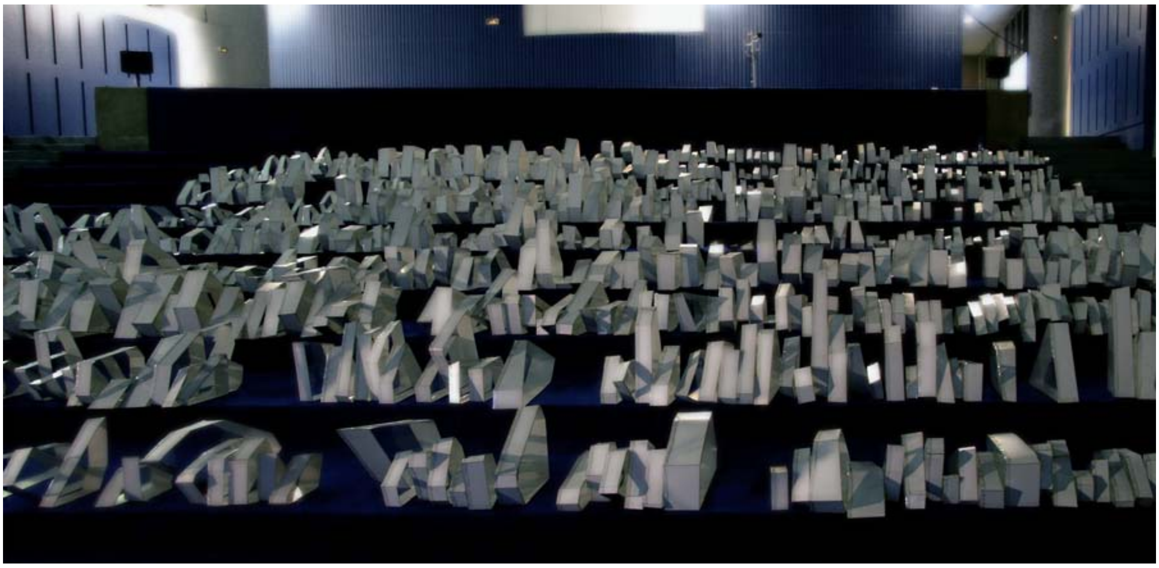

Fig. 2. The cells of the outer shell arranged in the order of assembly (photograph)

Methodology

The project's methodology was a first step towards an approach incorporating architectural form-finding, multi-media design and fabrication of building components in a unified performative process. In the foundation of this process are the protocols for the cross-platform data exchange. In the contemporary technological environment, all of the three areas utilize digital tools capable of programmable data-wrangling. The unified digital-fabrication workflow offers other benefits apart from convenience. Design via parameter-readjustment allows for work with relational diagrams. During development, the designer is able to, and in fact has to, move up and down the branches of the process tree, reviewing the feedback and readjusting the inputs. Even though everything in the computer system is ultimately solvable, the designer waives the right to control results explicitly and instead guides the process with multiple indirect measures. The sacrifice of direct subjective control leads to gains in the capacity to deal with complex systems holistically, without reducing them to basic components. The bifurcations of the process with which the designer becomes intimately involved often lead to solutions that could not have been pre-specified from the start as spatial layouts or even as design goals. The feedback is often real-time or comparatively fast. The ability to tweak different components of the process allows the designer to learn about system relationships via experimentation. It becomes possible to plot alternative design paths in terms of multiple sequential versions. This process of probing and recoiling is exploratory by nature. The design process acquires a character of an investigative tool rather than that of a method with which a wilful author promotes his or her worldview. Significantly, the design suggestions derived from the procedural design process can be very different from those intuited at the beginning. Insights gained in this way can both educate the designer and lead to innovative solutions.

It is often said that specification of the problem is part of the solution. Thus, educating the designer is a significant goal. Within this project, the educated designer was providing a vital link between the solvable system and the fuzzy reality of the in-world situation. As designers, we were aware of many practical circumstances such as constraints on resources, materials, money, time and knowledge or multiple design goals related to various stakeholders. The design process began when on-site observations were expressed in the digital domain in terms of virtual forces impacting upon geometric systems and proceeded as interactions between these systems and the designer.

The results had to satisfy a number of structural and experiential criteria. The most fundamental of these were cell sizes and proportions. A related negotiable criterion was the degree with which the cell-walls and cell-skins were able to conform to the curvilinearity of the input surfaces. Cell quantity, together with other parameters, would have a direct impact on the weight of the structure and the number of operations required for its production. Experientially, the iterative process looked to uncover the effects on visual density and variety of surface texture (Fig. 4), visual permeability along varying view lines and production of shadow patterns.

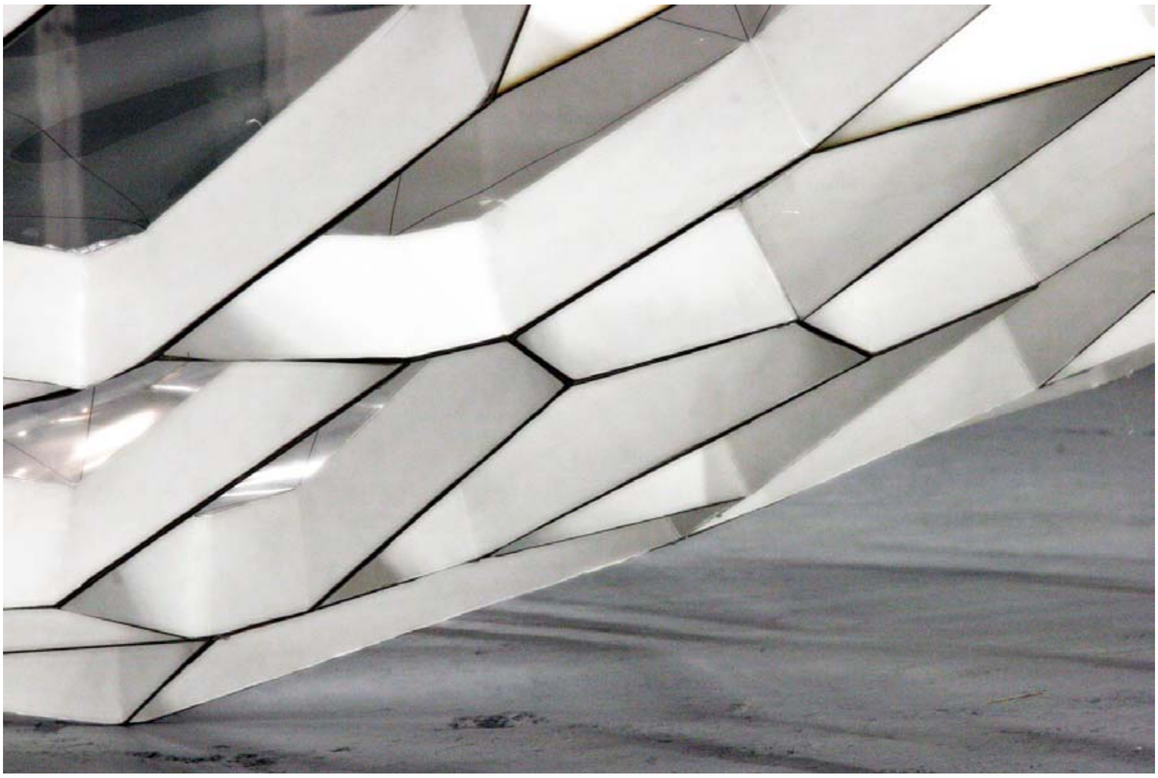

Fig. 3. A fragment of a cell-patch on the floor (photograph)

The curvature/density relationship as implemented in the custom-written scripts exemplified the adaptive capacity of the approach. Other procedural relationships of this kind can be established and the controlling input can be provided via on-site observations or computational methods. The examples of such data might include isovists/viewsheds, light-level and body-movement measurements or simulative AI routines. The parameters of the structure that might be driven by such data include fenestration; cell-skin and cell-wall transparency, colour, light reflectance, light transmittance and other material properties; cell-wall widths, cell-wall orientation, cell density, cell uniformity and the like. For example, the project featured experiments linking the orientation of the cell-walls to the positions of the video projectors. Such linking enabled the structure to guide the moving-image formation by opening or blocking light cones, controlling shadow distributions, framing views and articulating the sculptural properties of the structure.

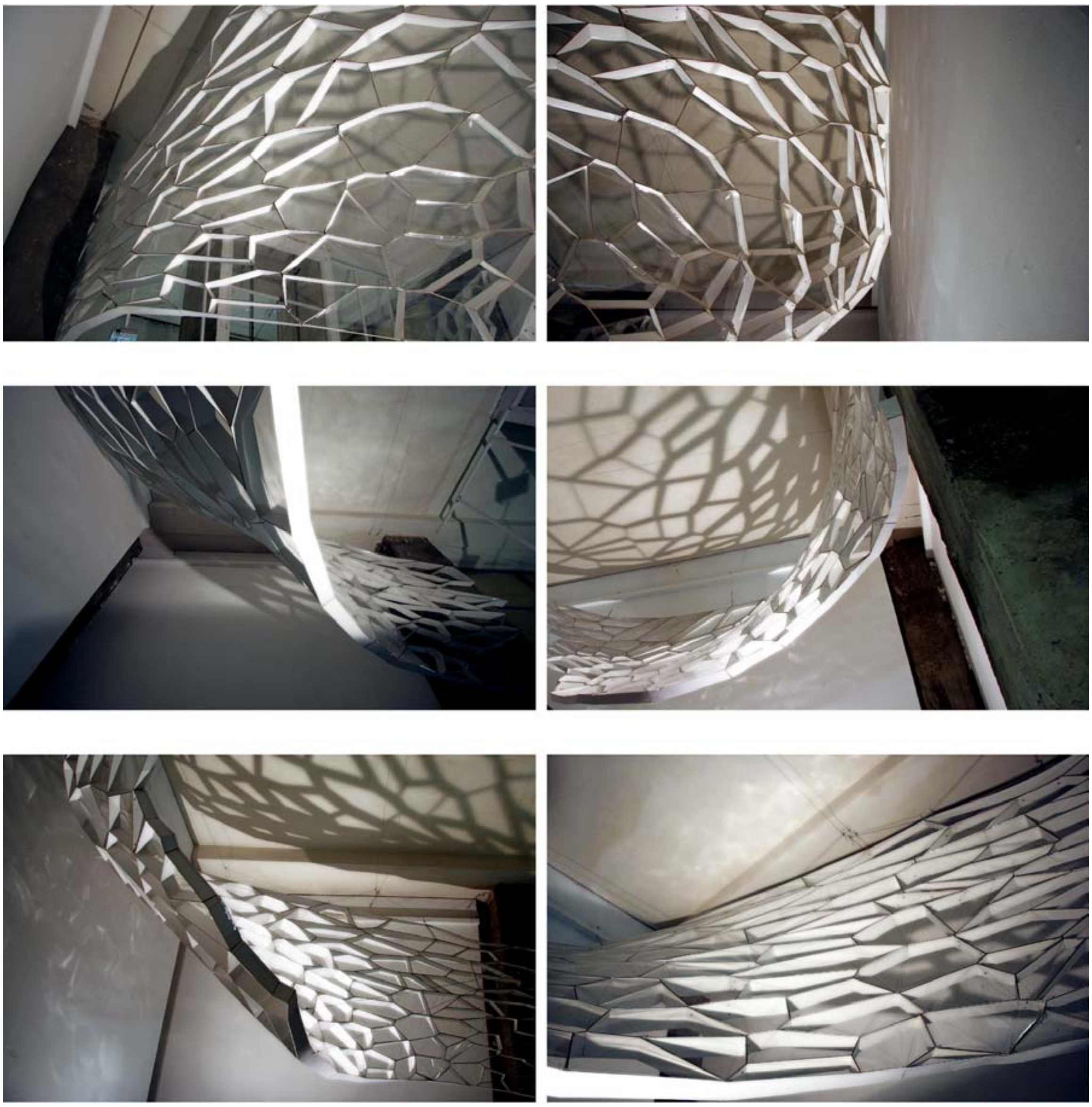

Fig. 4. Fragments of the structure installed in the stairwell showing variations in cell densities, cell-wall heights and cell-wall orientations (photographs)

The primary research aspiration behind this work was a desire to develop the backbone process that could illuminate the significant theoretical and practical issues and serve as a basis for future work. The experimentation has confirmed that adaptive non-periodic patterns such as Voronoi can be implemented into a procedural design workflow. This integration provided the first steps towards a unified design approach that considered place-specific form-finding together with custom-built audio-visual design. It was shown how structure uniformity and density, cell orientation, cell depth, and parameters of cell-skin can be procedurally fine-tuned as interrelated system components.

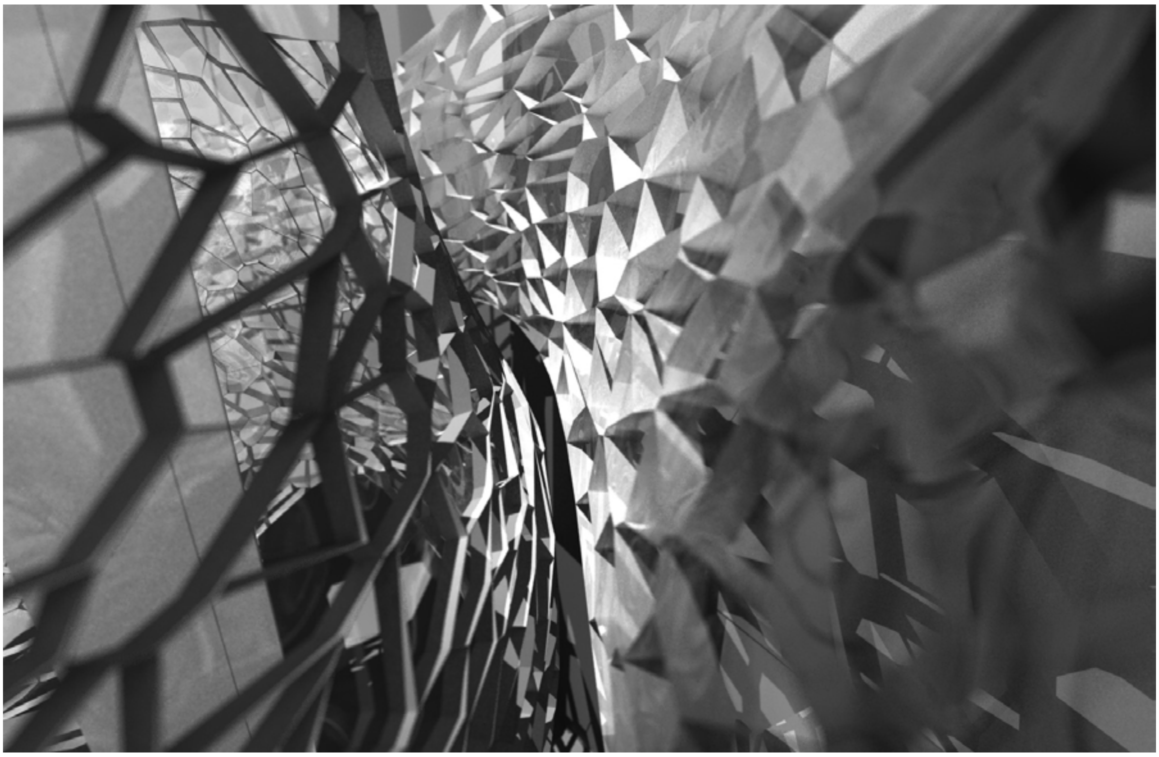

Fig. 5. A perspective along the direction of the inter-shell canyon (a digital rendering).

Future work might look at two areas: the use of patterns other then Voronoi and more intelligent generation of patterns. For example, Cambridge University's Department of Plant Sciences (2005) works on computational simulative models that strive to uncover the way plant-cells specialize, grow, adapt and make up complex structures via cell-to-cell interactions under the influence of local conditions. While this kind of research seeks to understand and modify the growth of plants it can also provide techniques and insights to inform the architectural design of adaptive structures able to host responsive performative situations. Morphogenetic models of growth and cell division can be adopted to and around a unified system able to satisfy the multiple spatio-mechanical, functional and performative factors of a complex design situation.

Interactive Media

The moving images were derived from dance, urban life and biology. These three distinct themes have, at the first glance, little in common. Yet, assembled into a dynamic collage, they exhibit striking similarities of temporal and spatial patterns. Visitors were able to explore the patterns of complexity, growth and self-organisation emerging from the interaction between this dynamic collage and the cell-based architectural structure. The sounds and melodies fluctuated in parallel with the visuals.

Pattern selection and sequencing in visuals and sound were governed by the character of visitors' movements through the stairwell. A video camera was installed to survey the "stage" before the disused lift. The amount and character of movement in its image stream determined the composition and energy of the interactive audio-visual response.

Fig. 6. A perspective of the stairwell (a digital rendering)

Performative Situations

Fundamental to the project was a theoretical perspective that understood architectural environments as time-bound performative situations made up of social, practical and motivational involvements. One of the project's ambitions was to establish a workflow that could lead to a synergy between traditional architectural concerns and the situations of direct engagement as developed by performance practitioners, game designers or, recently, by new media artists.

The goal was not to create a "beautiful" object but to set up conditions for the emergence of meaning. For example, the audio-visual field of the installation would come to life only with the arrival of people who cast shadows, moved through the structures, assumed and shed social stances. The installation did not have a meaning by itself, as a structure devoid of people. Rather, its meanings emerged as a story of tensions: between the perfect completeness of the digital and the untidy of the physical, between ambitious concepts and practical constraints, between goals seen as the desire to make objects and goals seen as playful exploration that is meaningful in its own right. The work on this project strived to develop and test the techniques that could help to erode the boundary between the digital and the physical by establishing multi-modal and open-ended design processes able to accept and guide imagination and respond to inputs normally left outside of the architectural domain.

For additional information on this project and the related concepts, refer to our formal papers (Artopoulos, 2006 and Roudavski, 2006).

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References

ARTOPOULOS, G., ROUDAVSKI, S. (alphabetically) and PENZ, F., 'Adaptive Generative Patters', in *Proceedings of The Second International Conference of the Arab Society for Computer Aided Architectural Design (ASCAAD 2006)*, ed. by Jamal Al-Qawasmi and Zaki Mallasi (Sharjah: The Arab Society for Computer Aided Architectural Design (ASCAAD), 2006)

ROUDAVSKI, S., ARTOPOULOS, G. (reverse alphabetical order) and François PENZ, F., 'Digital Design Techniques for Adaptable Systems: Prague Biennale Pavilion', in *GameSetAndMatch II: The Architecture Co-Laboratory on Computer Games, Advanced Geometries and Digital Technologies*, ed. by Kas Oosterhuis and Lukas Feireiss (Rotterdam: Episode Publishers, 2006)

KUDLESS, A., 2005. *Material Systems Organization* [online]. http://www.materialsystems.org/ [Accessed 9 November 2005].

WEISSTEIN, E. W., 2005. *Voronoi Diagram* [online]. http://mathworld.wolfram.com/VoronoiDiagram.html [Accessed 9 November 2005].