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Developing an Algorithm for Topological Transformation

Abstract

This research intends to test the architectural application of Jean Piaget's clinical observations, described in the book: *The Child's Conception of Space* (Piaget, 1956), according to which topology is an ordering discipline, active in the human psyche.

Earlier attempts, based on the principles of graph-theory, were able to cover only a narrow aspect of spatial relations, i.e. connectivity, and were mostly a-perceptual, visually mute.

The "Spaceprint" method, explained and illustrated in co-author's book: *Thought Palaces* (Magyar, 1999), through dimensional reduction, investigates volumetric, 3D characteristics and relationships with planar 2D configurations. These configurations, however, represent dual values: they are simultaneously the formal descriptors of both finite matter and (fragments of) infinite space. The so-called "Particular Spaceprint", as a tool of design development in building, object, or urban scales, with the help of digital technology, could express - again simultaneously - qualities of an idea-gram and the visual, even tactile aspects of material reality. With topological surface-transformations, the "General Spaceprints", these abstract yet visually active spatial formulas can be obtained.

Resumen

Esta indagación se propone de ensayar la aplicación de algunas observaciones clínicas elaboradas por Jean Piaget en su libro (Piaget, 1956), sobre la comprensión infantil del espacio según se encuentra la topología como una disciplina de ordenamiento vigente en el psiquis humano.

En algunas pruebas anteriores fundados en principios de teoría gráfica han podido abarcar solo un aspecto escaso de las relaciones espaciales, por ejemplo la conectividad, y por mayor parte eran imágenes mudos, o 'aperceptibles'.

El método 'espacio-estampa' ó Spaceprint explicado y ilustrado en el libro Thought Palaces (Magyar, 1999), lo cuál fue escrito por Peter Magyar investiga las características y las relaciones volumétricas tridimensionales con algunas configuraciones de imágenes planas en dos dimensiones. Sin embargo en estas configuraciones se representan valores duales: simultáneamente descriptors formales de la material finita y los trozos que se indica al espacio infinito. El nombrado spaceprint en particular como instrumento de desarrollo de diseño en varias escalas (objeto, edificio, urbana) con la asistencia de la tecnología digital podría expresar simultáneamente las calidades de una 'ideagrama' y los aspectos visuales, incluso los aspectos táctiles de la realidad material. Estas fórmulas espaciales e abstractas a la vez visualmente animadas podrían ser obtenidos por transformaciones de la superficie topológico, en particular por los spaceprints generales.

Topology and transformation

Our intent is to test and, with the help of digital imaging, illustrate the architectural application of the late Jean Piaget's clinical observations described in *The Child's Conception of Space* (Piaget, 1956) Piaget's book documents that several thousand pre-school age children were able to correctly reproduce set theoretical relationships before they could draw basic geometrical elements, such as a square, circle or triangle. These observations lead him to the conclusion that topology is an ordering principle; active and genetically present in the human psyche. Architecturally this premise suggests the fundamental importance of the relationship of spaces one to another.

This research begins by accepting the following parameters:

The relationship of spaces one to another is fundamental to our spatial cognition.

Our perception of space is based upon the configuration of perceived surface conditions.

In the course of these inquiries we have asked and are attempting to answer the following questions:

Are there relational parameters, separate from formal or scalar variations, which are common to successful and/or powerful buildings? (How will we define "success" and "power" in terms of a building?)

How may we develop and communicate architectural ideas in a manner that emphasizes the relational characteristics?

How may we teach architectural form-making wherein relational hierarchies precede other aspects of formal development?

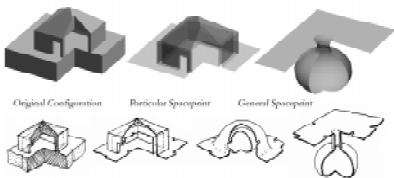


figure 1 - topological progression from original configuration to Particular Spaceprint to General Spaceprint

In order to apply topological transformations to an architectural context, a simultaneous promotion/demotion is needed in the protocol of traditional architectural delineation. Lines are replaced by surfaces: a wall surface is understood simultaneously in two axes. Instead of lines, as elements of design, surfaces are applied. On the other hand, solid volumes, traditionally rendered with material thickness, are reduced: rendered using the same planar skins. This space can be conceptually reduced to its boundaries or interfaces wherein two-dimensional components surround it providing a simplified description of its spatial complexities. This advancement from one to two dimensions, and the reduction from three to two dimensions, is played out in its extreme as the boundaries of any one topological model recede into the infinite surface of ground. The interface that is both a part of the Earth (for example) and spatial infinity is dubbed as “Cosmic Spaceprint”, and its fragment as “Particular Spaceprint” (figure 1). These interface fragments (Spaceprints) are simultaneously describing the forms of finite matter and (a limited domain of) infinite space.

Digital modeling tools are particularly well suited to these inquiries. Using auto-des-sys form•Z and alias Maya2 software - we may render two-dimensional surfaces as discreet elements without any illusion of thickness. We may begin defining space without the particulars of mass. Furthermore, with an essentially limitless page size the metaphor of the Cosmic Spaceprint is maintained.

Topology as delineation

We recognize a paradox between architects verbally addressing the qualities of space in their design descriptions, while graphically presenting the images of the non-space elements, i.e. the solid matter of a building. Within the dual category of space and matter we have to call attention to the shift from space defined by structural material (stone, brick, concrete) to space defined by surface materials (veneers) where the spatial boundaries are delineated by thin slabs of matter conceptually close to a two-dimensional surface. Three-dimensional surface drawings can indicate material differentiation simultaneously with form. The spatial boundaries transcend the image of an idea to reveal the image of a particular occupancy condition.

Architectural ideas can be described verbally, but their generation and manifestation best happens in a three-dimensional spatial form. Materiality is undividedly related to them. We intend - as part of our ongoing research - to refine the application of digital imaging techniques to our investigations, with special attention to providing raw materials to cognitive and visual analysis in architectural and urban design.

Stage one: greek temples

We began this process by modeling six Greek temples. They were initially modeled as three-dimensional solids and then rebuilt as continuous skin models. Their plan simplicity is sharply contrasted by the spatial variations communicated in the first generation of digital topology models. While traditional plan drawing does not substantially differentiate between a screen wall and a colonnade the topological condition of the columns reveals a less reducible tube anomaly. The models were rendered as translucent material so students might better visualize the continuity of surfaces (figures 2,3,4,5).

After exposing students to the translucent renderings students were shown animated walkthroughs of the models, this time rendered as opaque material. The animations proving that the surface models were in fact connected to the way they typically perceive space, despite the digital model's obvious lack of material mass.

The most recent development in this work has been a detailed model of the Pantheon developed in Maya. The interior surface of the main space is modeled as an articulated skin (figure 6).

Stage two: transformative modeling toward general topologies

So far this inquiry has been limited to fixed levels of abstraction when considering the topological models. Using the organic modeling and animation opportunities in Maya the next phase of inquiry looks to develop a method wherein transformation routines may be applied to the topology models to abstract the starting conditions of scale and proportion and, once the appropriate algorithms have been developed, to transform Particular Spaceprints into General Spaceprints. If surface abstraction methods can be determined and applied with consistent results then many different buildings could be compared topologically and a catalog of effective and common relational configurations might be developed.

References

Magyar, P. (1999). *Thought Palaces*. Amsterdam:Architectura & Natura Press.

Piaget, J., et al. (1956). *The Child's Conception of Space*. New York: The Humanities Press.

With a transformative modeling tool we also hope to examine the intermediate steps between the Particular and the Generic with consideration of where, in this metamorphosis, the specific form of individual buildings became unclear.

Stage three: generative topological modeling

It is our hope that by developing a dynamic transformation tool, animating all steps in the transformation, that this modeler may eventually serve to generate finite solutions from a general topology model (General Spaceprint). To develop a degenerative modeler, in stage two, we will need to determine algorithms for reducing the specific facets of a particular form into adjacent curvilinear surfaces. We expect that the protocol for degenerating flat planes into curved surfaces may ultimately be reversible if the abstract topologies include adequate surface tessellation.

Recognizing that our descriptions have been general it is our hope that this brief explanation serves to communicate our intentions for topological analysis, the applicability of the illustrated methods for communicating spatial configurations, and the future directions of our research. We look forward to sharing further developments and conclusions as this work progresses.

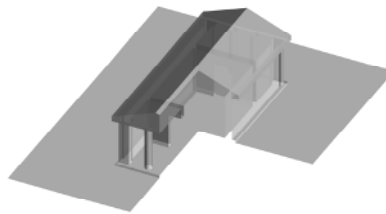


figure 3 - Particular Spaceprint: typical temple, Amphi-Antis Distyle

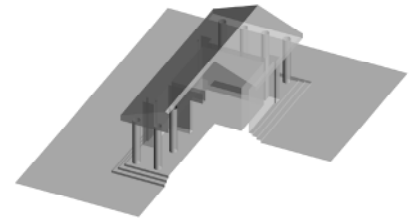


figure 4 - Particular Spaceprint: Temple on the Illissus

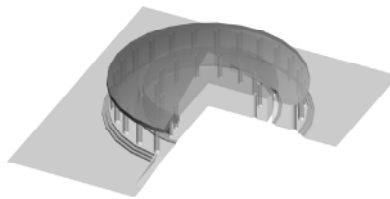


figure 5 - Particular Spaceprint: Tholos of Polycleitos

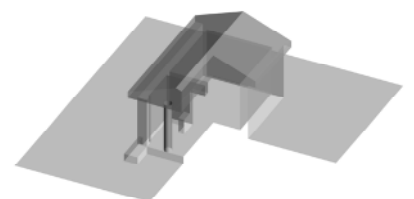


figure 2 - Particular Spaceprint: Temple of Nemesis

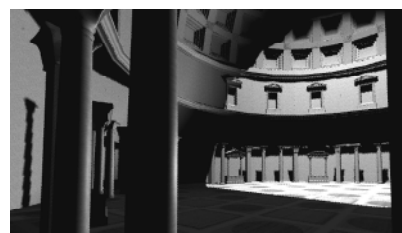


figure 6 - Surface Model of the Pantheon, in process