XIV del 1 al 5 de diciembre de 2008 CONVENCIÓN CIENTÍFICA DE INGENIERÍA Y ARQUITECTURA
ANIVERSARIO 44 cujae 2008
Congreso SIGraDi Cuba 2008 — Gráfica Digital Integración y Desarrollo — La Habana 1 al 5 Diciembre 2008

Study of digital morphing tools in the architectural design process

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Abstract:

This research work examines methods of experimental designing with CAD in a CAD laboratory with Architecture students. Thereby the main focus is on the early phase of finding forms, in which different techniques with digital media are tried out in the didactic architectural design lessons.

A morphological design involving CAD research and architecture theory as well as techniques to improve the design process are examined.

A digital city model is the starting point of the design process to guarantee the reference to reality. On the subject of morphology, a form-generating method in the pre-design phase has been tested. Starting from urban planning lines on an area map, two simple geometric initial images were produced which were merged by means of morphing software. For this purpose 2D based software like Morphit® ®1.01, Winmorph® ®3.01 and other freeware was used, whereas in the further development of this design technique we tested 3D freeware morphing programs like Zhu-3D® 4.1.2 or Blender® 2.47. The resulting morphological shapes were imported in AutoCAD® and refined.

In this research work, the properties and benefits of the morphing tools are presented and are analyzed with regard to the architectural shape generating in an urban context.

***Key Words*— architectural design, AutoCAD®, freeware morphing tools.**

I. INTRODUCTION

A. The term morph is linguistically defined as the smallest formal component of speech [1]. Morphology: 1: a branch of biology that deals with the form and structure of animals and plants b: the form and structure of an organism or any of its parts; 2: a study and description of word formation (as inflection, derivation, and compounding) in language b: the system of word-forming elements and processes in a language 3: a study of structure or form [2]. The third definition is applied to architecture.

In this presentation, the term "morphological architecture" refers to structures in which a basic object evolves to another object through a defined sequence; Ben von Berkel, Greg Lynn, Peter Eisenman and others are examples of architects who have applied this design style in their most recent submissions to competitions. Such architectures frequently create attractive interior space constellations. The current debate questions their relevance to city areas, and a conglomeration of solitary buildings is associated with a loss of urbanism.

The goal of this study is the experimental development of morphological design methods closely associated with urban development. The methods described here are based on urban planning lines in a digital model of a city. The potential of 2D and 3D morphing programs during the preliminary drafting stage was examined and compared. Both freeware and commercial programs were considered.

B. Morphological Architecture in the Discourse of Architecture and CAD History

Architecture is static. Architects have attempted to incorporate motion since modern times. The static house is intended to gain dynamics through association with kinetics and conform to modern ways of life. For his design, Le Corbusier created concepts that manifest and accompany the idea of the design in the planning process. He called them ideal types. Some examples are forms that have proven their kinetic merit, such as the ocean liner, the airplane and the automobile. [3] The morphological sequences as constructed architecture attempt to go beyond an association and to

transport dynamics into the structure - a process similar to animated images.

Like Le Corbusier, Ungers is an architect who firmly anchors mathematic and metaphorical aspects in his design theory. He writes in his book on the exploration of architecture that architecture without a primary theme is barren of thought. He seeks to compare architecture with painting and sculpture: " … while these disciplines can reproduce themes which they choose on their own, architecture and music must rely on topics that they can transform and vary.[4] Similar to the Russian matryoshkas, or nested dolls, the "house within a house" was one of Unger's themes that was implemented in the Deutsches Architekturmuseum (German Architecture Museum) in Frankfurt am Main. The concept here was "the transformation of space as indefinite continuity of interior and exterior." [5] Prototypes for such shell architecture are sacred structures like the temple in the Old Testament, at the core of which, surrounded by colonnades and outer walls, the most sacred objects were accessible only to the holiest.

C. Typologies in Architecture and the Derived CAD Application

In the history of architecture typology, Jean-Nicolas-Louis Durand used simple shapes such as the circle, square, simple coordinate system, symmetrical building complexes and primary structural elements in the floor and lateral plans in his textbooks from the period 1790-1830. [6] CAAD research has rediscovered the fundamental significance of Durand's building typology and is attempting to develop it further and implement elements thereof in CAD environments. Kahn, an architect of the atmosphere, said on the other hand: "Every space needs its own definition for what we intend it to do, and its exterior grows from this …" [7] As did Christopher Alexander in his tree structure decomposition of urban planning stemming from architectonic archetypes, he chose "pattern language," a deformation process that analyzes the character of main elements. He declared the architectonic space to be the smallest unit, and its criterion is the atmosphere of the space to be created - the materialization of which is secondary. The university teachers Rivka and Robert Oxman issued exercises titled "Refinement and Adaptation," in which a syntactical model of shape generation is examined. Using two examples, floor plans were analyzed and merged based on certain predefined rules. Studies of the Exeter Library and Kahn's Goldenberg House showed the same basic grid; Mario Botta's villa Pregassona was converted to the Villa Massagno in five steps.[8] In both analyses, a floor plan evolved morphologically to a new floor plan. The typology according to Durand is an abstraction that prepares for creativity.

D. Image Morphology

On the basis of the Durand shapes, Ungers began to compile an encyclopedia of space and structure forms. He called his principle a morphological shape transformation based on the three basic shapes: circle, square and triangle. [9] His work was never finished, but it had an influence on the design technique in numerous projects and was applied to shapes, objects, spaces and themes that evolved through history. I conducted two experiments on the topic of image morphology. The first used an image editing program in which the pixel size of the digital picture "Aeroplane flying" by Malevich was enlarged step by step with a so-called mosaic filter. The change to the picture reflected an increasingly large distance with a constant image section in which the melting pixels could be seen sharply.

DESIGN EXPERIMENT WITH AN IMAGE EDITING SOFTWARE

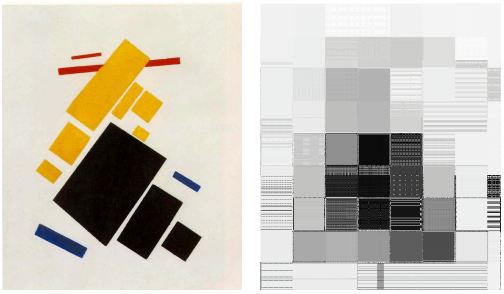

Fig. 1. First, Malevich, "Aeroplane Flying"; second, deconstruction of that picture done by a mosaic filter.

In this experiment, an architectural idea was created playfully from a 2D image. [10]

II. MATERIAL AND METHODS USED TO COMPARE SOFTWARE

This project examines techniques for the CAD-based design process for morphological architectures as a complement to standard AutoCAD® software, which offers the possibility of taking unformed shapes and using polygons to design a morphologically shaped structure as a mesh; the next step fails though, because the mesh cannot be converted to a body on which cross-section and extrusions can be performed. This is why morphing tools from other programs are tried out for this design technique. An essential criterion was how the morphological intermediary results were imported and also the possible options for further processing: The data format and the generated AutoCAD® object type, such as 3D surface, polylines or volume model are relevant here. The morphing tools were all tested the same way in an urban planning situation. Two outlines – the floor plan and the roof level – were used.

The structure of a six-story building was to be generated between the two parameters. Other criteria evaluated were the ease of use and the complexity of the software as well as the methods applied to created a morphological cubature.

A. Results of the Analysis of the Software Competence for the Morphological Architecture Design

List of the tested 2D programs, based on pixels: Morphit® ®1.01(freeware) [9]; WinMorph®3.01(freeware) [10]; Photoshop ®CS2 (commercial).

URBAN SITUATION FOR THE DESIGN SKETCH

Fig. 2. Showing the ground- and roofline for the morphological sketch in a digital city model. Rendering from AutoCAD.

The 2D pixel-oriented programs created morphological animations. The image sequences were converted back to individual pictures to be imported into AutoCAD® with a conversion program, e.g. Main Actor® 5.51 – Sequencer [11]. These programs work with two or three windows: Original image – target image – morphological sequence.

WinMorph® links inserted points from the target image for the animation with points from the original image, while the older Morphit® works with a surface grid of triangles. Unfortunately, Morphit® can only transform a continuous area and is limited to image sizes of 248 x 200 pixels in gif black/white format. WinMorph® and Photoshop use cross fading effects and cannot be limited to mere surface transformation.

RESULTS OF MORPHS BETWEEN GROUND- AND ROOFLINE

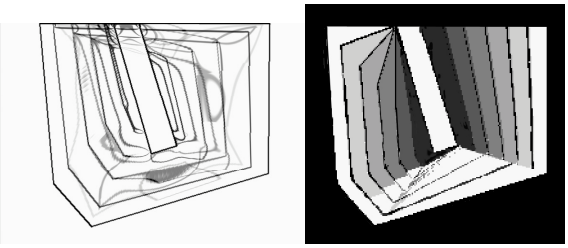

Fig. 3. First: Result from Blender®; second: Result from Morphit®.

So Morphit® proved to be the best program for calculating the story contours. The number of stories is defined by the quantity of frames, such that the calculated story outline is visible in the last frame. This pixel image is inserted into AutoCAD®, traced with polylines, and then developed to a volume model. Vertical extrusion creates a stepped architecture.

List of the tested 3D programs: Blender®2.47 (freeware) [12]; ZHu-3D®4.02 (freeware) [13]; Cinema 4D® (commercial)

The purpose of using a 3D program is to create levels or structures that can be imported into AutoCAD® and refined to an architecture model. The two freeware programs Blender® and ZHu-3D®, as well as the commercial program Cinema 4D®, were tested for this purpose. The logic of these programs is vastly different than that of pixel-oriented programs, beginning with the input methods, and in addition to the morphology function they have modeling and animation features.

Blender® has a dxf import and export interface and enables polygon meshes, curves and NURBS to be designed. AutoCAD® polygon meshes are the basis of data exchange. Also, morphological animations can be generated with key frames. Blender® can read and write Targa and Jpeg.

ZHu-3D® visualizes mathematic functions. There are three different ways to enter information: Explicit functions, different parameters or isosurfaces (algorithm based on volume). The user can apply his own or pre-defined functions. The morphing and animation features can reflect the entered equations as animated images in realtime.

Both programs create visually convincing morphical animations, but they are only suited to a limited extent to this task. Blender® only has polygon grids available via an interface with AutoCAD®, and ZHu-3D® allows data transfer only through pixel images. Both programs are extremely user-unfriendly to CAD users.

Cinema 4D® offers a very pleasant environment for these operations: Curves are created for the outlines. The curves are generated with loft NURBS as the structure shell. At this point, little effort was required to generate variations of structures, insert them in the digital city model and examine them architectonically. The number of stories can be defined by adjusting the density of the mesh. The created NURBS are transformed to polygon objects and the side lateral surfaces are deleted. The resulting horizontal polygons are filled with surfaces. These must be converted to regions in AutoCAD® to then be able to be united. Then a volume model can be generated through extrusion. Amongst the options tested, this data transfer was the most successful, because a volume model could be generated directly from the data.

B. Example of digital designing in urban space

On the subject of morphology a form-generating method in the pre-design phase has been tested by students with Morphit and AutoCAD.

The students were given an inner-city site, which was being

RESULT OF A MORPH BETWEEN GROUND- AND ROOFLINE

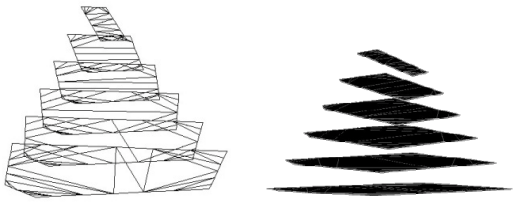

Fig. 4. First: polygons; second: polygons filled with surfaces (both modeled by Cinema 4D®, Dr. U. Mylatz).

MORPHOLOGICAL MODEL IN A DIGITAL CITY MODEL

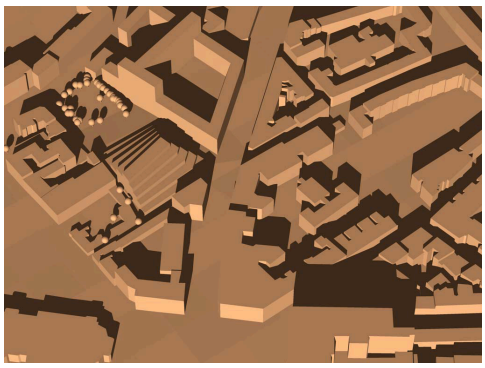

Fig. 5. Design result from Cinema 4D® imported in AutoCAD®

used as a car park at the time, to work on. Their task was to focus the buildings ringing the site, consisting of half-timbered houses, a high-rise building and mid-Victorian houses, to form a morphological building as a development of the site. In the visualization phase, the individual images were materialized by projecting them on to glass.

In the early phase especially, the integration of software from other artistic and academic disciplines can lead students to creative use of the computer and open up new design methods beyond "bottom up" and "top down" techniques.

III. Conclusion

RESULTS OF STUDENTS DESIGN EXERCISE

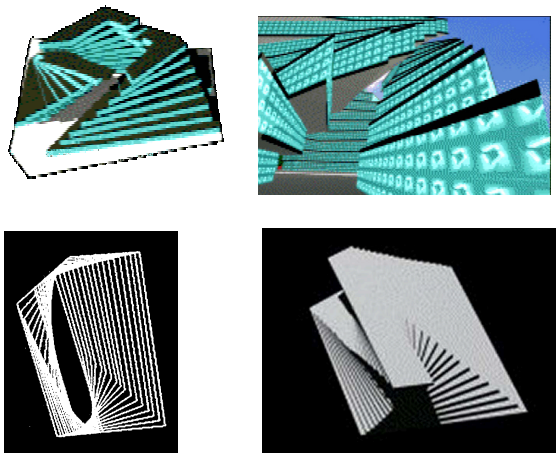

Fig. 6. morphological image sequence and building conception. Students, C.Büsch, M. Nommensen

The goal of this study was to develop a method for morphological architecture design that could be used with standard CAD software for project work, in this case AutoCAD® . In AutoCAD® , freely modeled shapes can not be converted to volume models and thus have only limited use. Various 2D and 3D programs were tested, some of them freeware, some commercial. Of the 2D programs, Morphit® proved to be the most effective. Unlike the other pixel-oriented programs, which apply cross-fading, shapes were transformed. The user guidance is self-explanatory in this small program; only the limitation of the file formats and the image sizes requires some previous knowledge.

The freeware 3D programs tested posed high requirements of the user; their complex input logics are not comparable to standard CAD programs. With the commercial program 4D Cinema®, objects could be created intuitively, and the program thoroughly fulfilled the criteria for the previously defined design technique. The generated objects were relatively easy to import into AutoCAD® and to then process further. Of all the complex features of 4D Cinema, only a few of the commands are needed for morphological design. The creative design process could be best supported with the software.

It could become a component of basic design instructions to teach students to test different approaches to the design process with the goal of finding their own methods such as the multimedia CAD technique described here. Playful design procedures applying media are often surprisingly productive and are just as indispensable as hand-drawn sketches.

Acknowledgment

I wish to thank very much in particular, Dr. Uwe Mylatz, lecturer, Leuphana Universität Lüneburg for his support in Cinema 4D®, Matthias Testa, student of engineering, for his work with Zhu-3D® and Theo Kirschner, high school pupil, for his help in Blender®. To Dr. Peter Kreutzmann goes gratitude for his cooperation.

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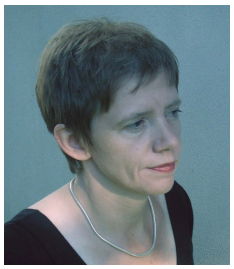

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