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Design from Known to New

-Issues of Generative Architecture under Digital Environment-

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Abstract

Given the power of digital design media, architects are confronting a new territory of architectural morphology. This paper attempts to explore the issues of generative architecture under digital environment. It is concerned with architectural precedents, their morphological attributes, and morphological analysis as the point of departure for generating new designs. Three design experiments are employed for the exploration. The first experiment addresses the issue of a single building. The second experiment focuses on the problem of urban architecture. The third design experiment places emphasis on the issue of urban landform.

In addition to the exciting novel forms and spaces generated from the afore-mentioned design experiments, a number of critical issues on generative architecture are raised and discussed in the paper. Among them are: (1) the concept and logic underlying the methodology of the design experiments; (2) the formulation of the generative design systems utilizing the existing morphological structures; (3) the employment of the digital design media (e.g. image processing, 3D abstraction and extrusion) for various purposes during the process of analysis and generation.

1. Background

Given the power of digital design media, architects are confronting a new territory of architectural morphology. For example, the topological form generated by the mechanism of S-pline is widely accepted by some contemporary architects such as Greg Lynn. [1-2] Innovative architectural projects developed with powerful concepts under digital environment have also achieved acclaim in recent years such as FOA's Yokohama International Port Terminal. [3-5] It is thus arguable that crucial issues involved in the application of digital media in the process and/or the product of architectural design deserve a closer examination.

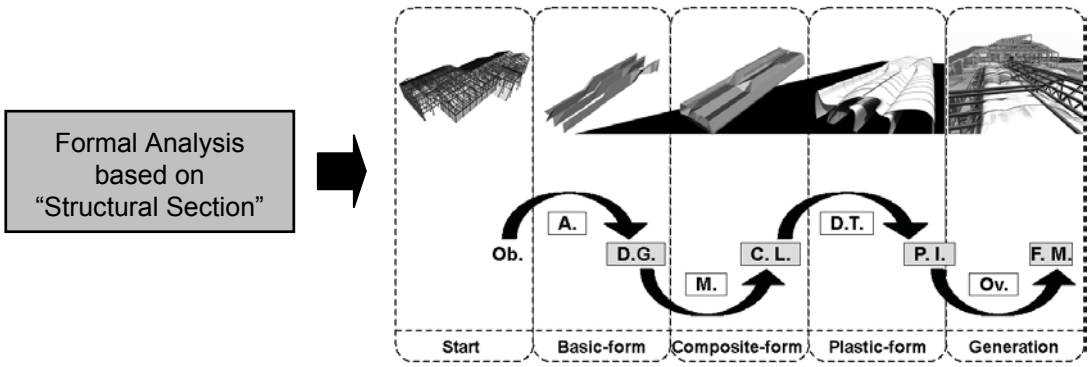
2. Three Design Experiments

This paper attempts to explore the issues of generative architecture under digital environment. It is concerned with architectural precedents, their morphological attributes, and morphological analysis as the point of departure for generating new designs. Three design experiments are employed for the exploration. The first experiment addresses the issue of a single building. The second experiment focuses on the problem of urban architecture. The

third design experiment places emphasis on the issue of urban landform. They are shown as follows.

2.1 Experiment I: Design from Existing Structural Elements

The first experiment addresses the issue of a single building. The overall process of the experiment is shown in Figure 1. A method for analysing the formal structure of an existing building is developed on the basis of "structural section." The process of generation consists of two steps: the derivation of basic form and the development of complex form. The major operation involved in the process is called "differential generation," "Migration," and "Constructive Linkage." (Figure 3) The derived form is further explored through the operations of "differential transformation" and "plastic integration," as well as "overlapping," and "movement." (Figure 4) For the generation of final plastic form, four types of structural and spatial overlaps are identified. (Figure 2)



Ob.: Object; A.: Analysis; D.G.: Differential Generation; M.: Migration; C.L.: Constructive Linkage
D.T.: Differential Transformation; P.I.: Plastic Integration; Ov.: Overlap; F.M.: Flexible Movement

Figure 1. Overall Process of the Formal Operation

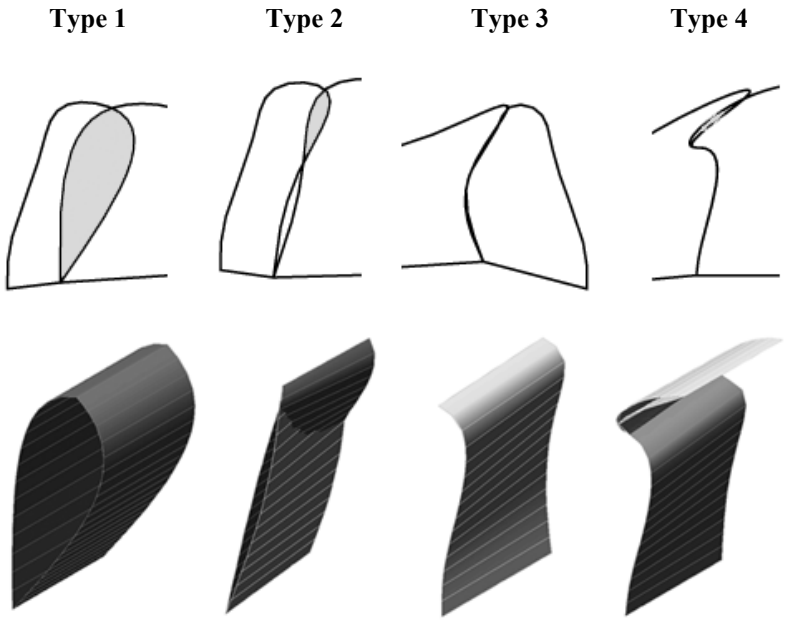


Figure 2. Types of Structural and Spatial Overlaps in Generation

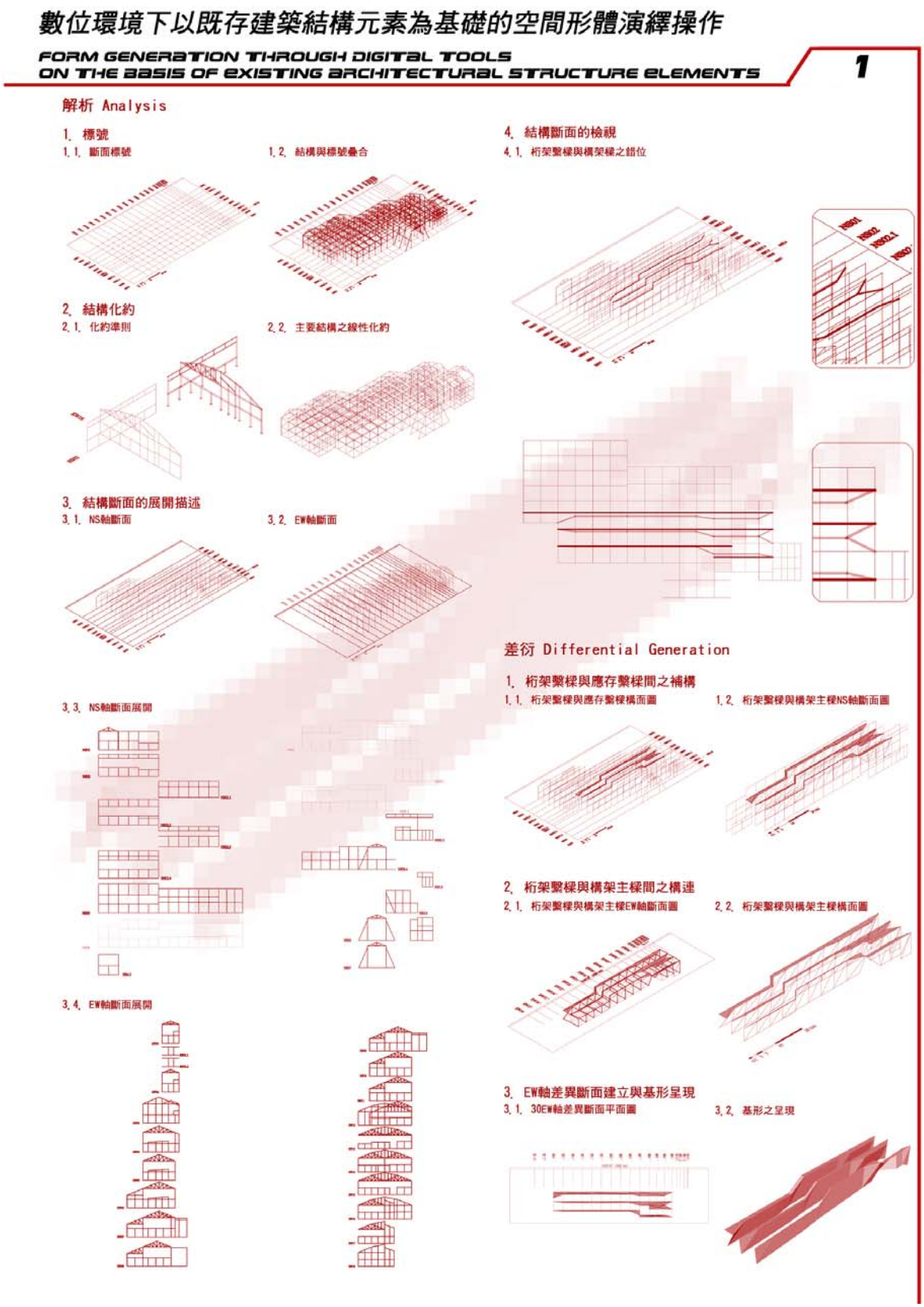


Figure 3. Analysis and Differential Generation

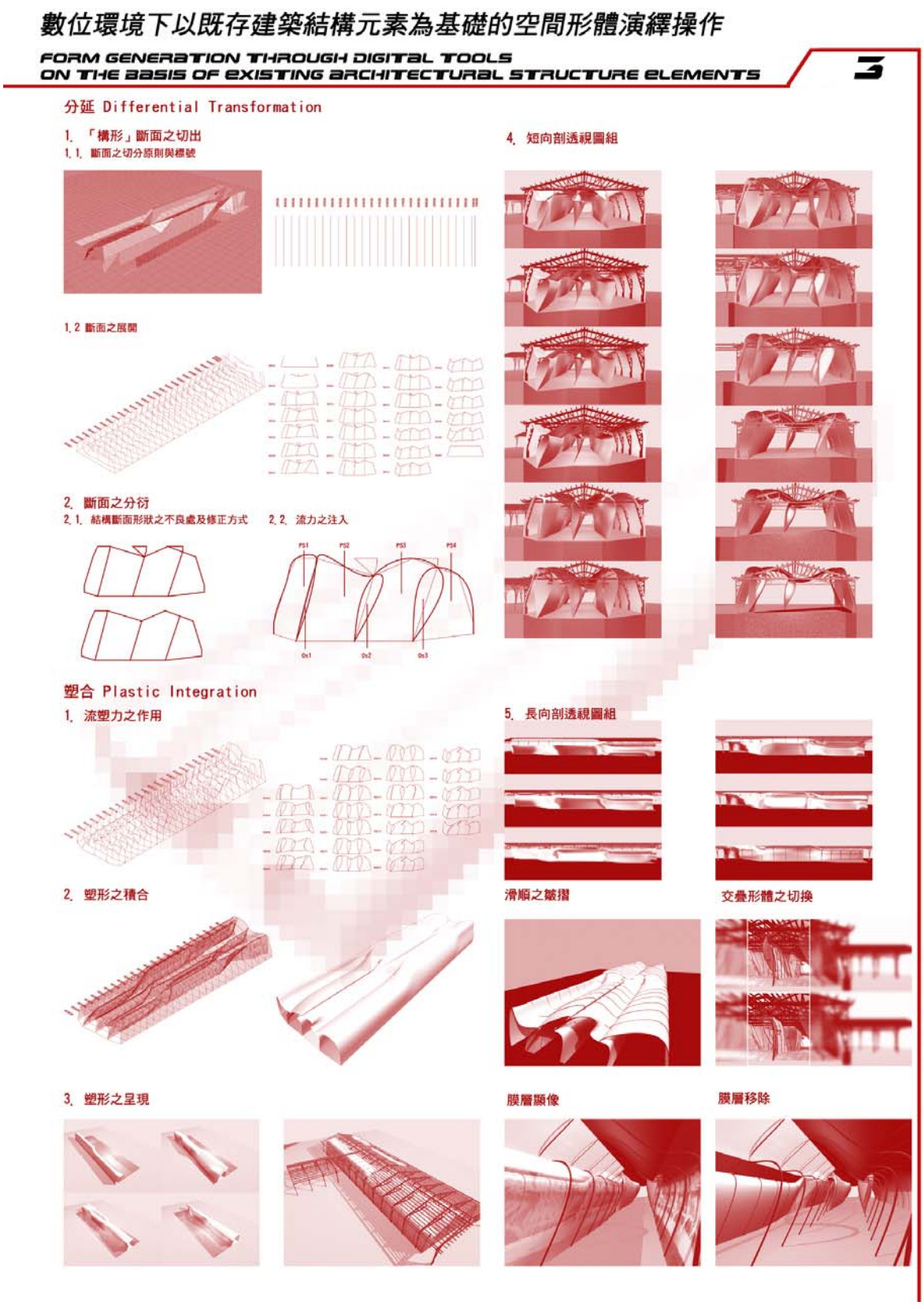


Figure 4. Differential Transformation and Plastic Integration

2.2 Experiment II: Design Based on Image-Space Methodology

The second experiment focuses on the problem of urban architecture. The spatial elements, which constitute the "skins" of the streets and the buildings of the city blocks, are investigated. The images of the past and the present "skins" are collected, compared and analyzed. An image-space methodology is developed to deal with the generation of the urban "skins" from 2D images to 3D spaces. It can be applied to address the problems of "deep," "shallow," and "planar" skins, respectively. Underlying the methodology is the notion of "Infra-Surface," which is based on the philosophical theories of Deleuze and Duchamp. As shown in Figure 5, the procedure of the experiment is divided into three parts; each part consists of two stages, and each stage has a number of steps.

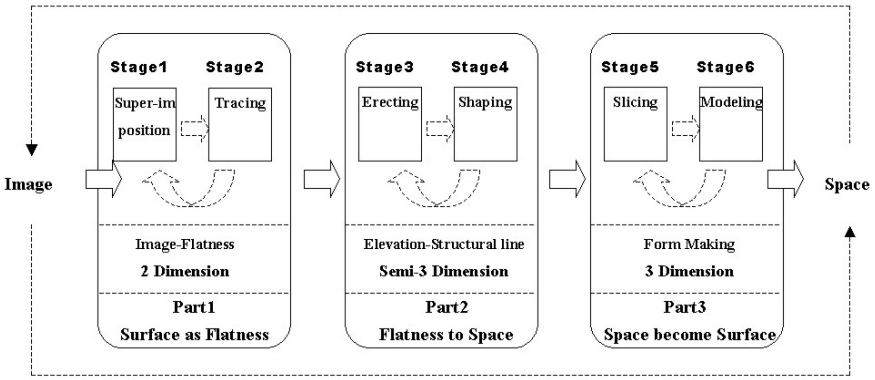


Figure 5. Procedure of Image-Space Methodology

Part 1 Surface as Flatness (2D)
Stage 1 Superimposing Images: to collect, select, and superimpose the images of the past and the present images to derive a precisely positioned, overlapped image.
Stage 2 Tracing Structural Lines: to trace the crucial contour lines of the overlapped skins in the image. The vanishing point and the new spatial relations are established

Part 2 Flatness to Space (between 2D and 3D)
Stage 3 Erecting Perspective Structure: to erect the spatial structure from perspective. The space produces certain semi-space effect.
Stage 4 Shaping Initial Form: to derive and edit the initial form through the definition of "infra-surface."

Part 3 Space to Surface (3D)
Stage 5 Slicing Initial Form: to simplify the complex wire frame and erase the redundant lines to derive a set of sectional slices for forming a new frame structure.
Stage 6 Modelling space: to complete the envelope for the structure and to add thickness for the structural surface.

Three building sites in Taichung City, Taiwan are selected to test the applicability of the procedure. They represent three different problems of "skin" design in urban architecture: deep, shallow, and planar. Some reasonable architectural programs are assumed for the experiment, such as exhibition, theatre, gallery, and commercial shops. The designs for the three sites are shown in Figure 6.

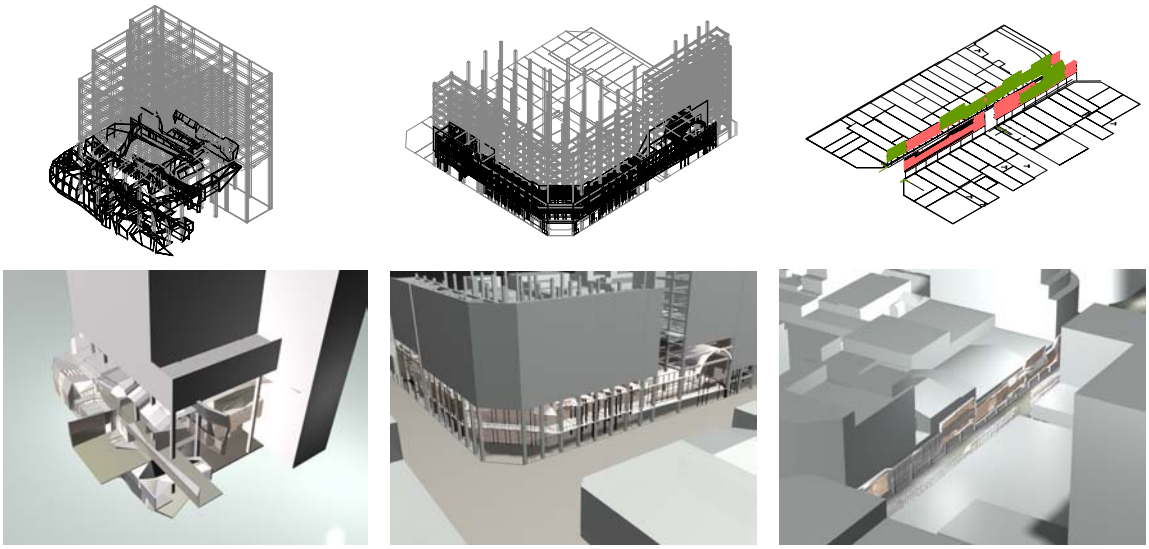


Figure 6. Derived Designs with Deep (Left), Shallow (Middle), and Planar (Right) skins

2.3 Experiment III: Design through Wire-Frame and Graphic Analysis

The third design experiment places emphasis on the issue of urban landform. Three classes of urban landform are identified: district, city block, and building. They are made up of city blocks, buildings, and structural elements, respectively. Wire-frame and graphic analysis are employed for analysis and generation. Specifically, a computer-based framework for the generative meshes at the three levels of hierarchy is established. The framework consists of four operations: "clustering," "tracing," "blurring," and "weaving." Figure 6 illustrates the process of transforming urban grid/mesh to wire-frame diagram and land surface.

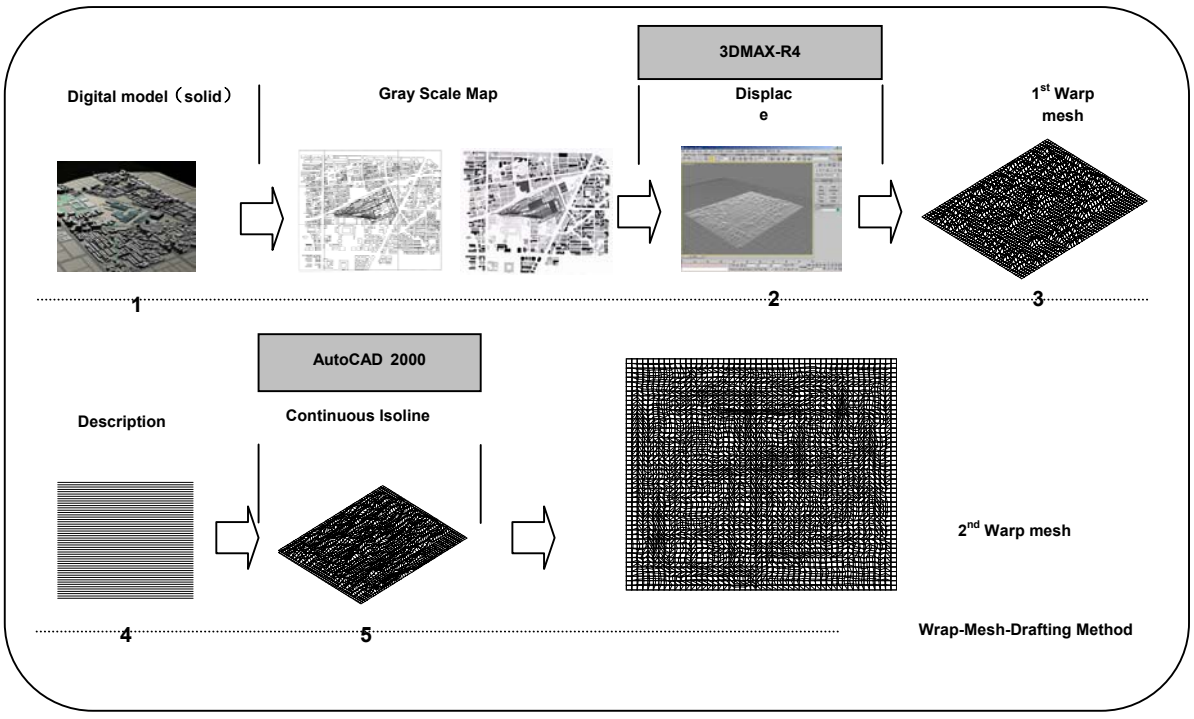


Figure 7. Wire-Frame Analysis and Generation

On the basis of the wire-frame analysis for the urban landform, a building design experiment is conducted. It consists of two parts. The first part deals with an existing building, in which the derived urban mesh intervenes for finding corresponding relations with the building. The intervention provides an opportunity for developing a new form that may arguably create certain spatial relations with the existing formal condition. The second part of the design experiment defines the "land surface" as the interface for architectural form. It uses the wire-frame as a fundamental form for development. It is followed by a series of formal operations between wire mesh, existing building, and the urban landform and thus establishing a new spatial relation among them. (Figure 8)

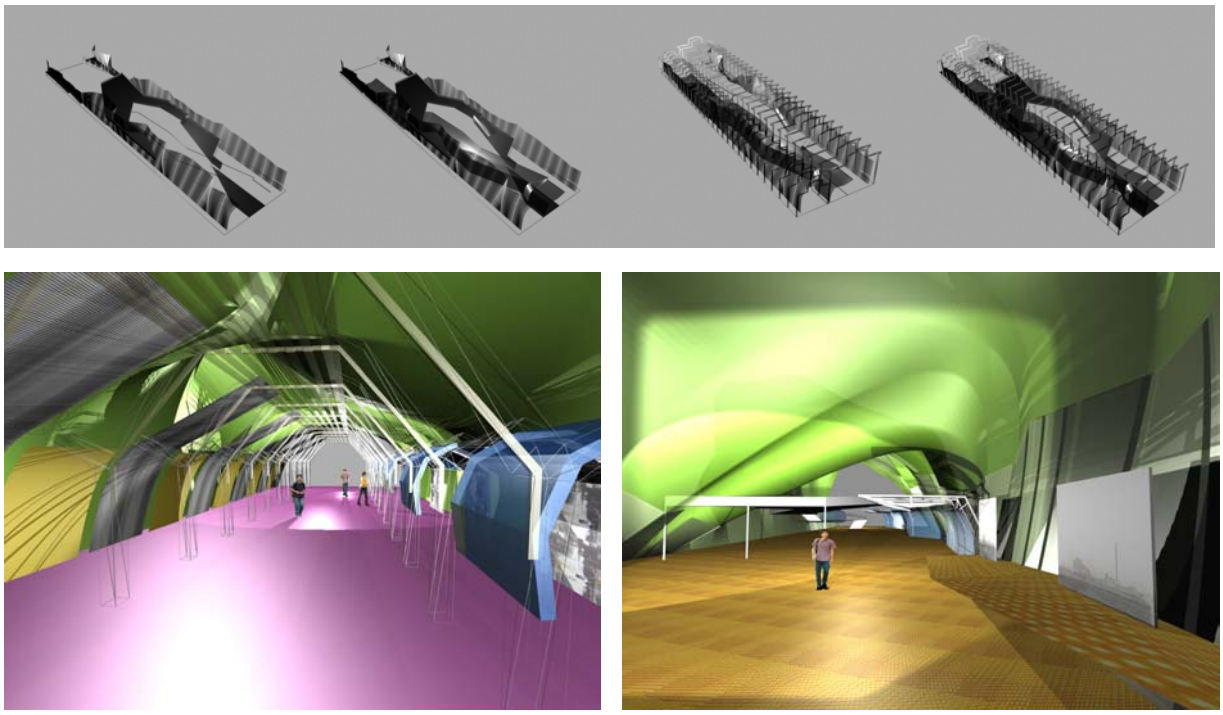


Figure 8. Process of Formal Operations and Two Interior Views

3. Discussion

In the afore-mentioned three design experiments, many exciting novel forms and spaces are generated. Specifically, the first experiment deals with design from existing structural elements. After a detailed analysis based on structural section, a procedure is developed for the generation of plastic form, which is different from the typical “topological form” and may be termed as “wavy form." The second experiment generates design based on image-space methodology. The images of the past and the present “skins” are incorporated to generate the three types of urban surfaces. The final forms exhibit the potential of the “infra-surface” that constitutes the skins of urban streets and buildings. The third experiment generates design through wire-frame and graphic analysis. Emphasis is placed on the spatial relations between the existing building and its surrounding urban landform. It is notable that many hidden, critical spaces can be identified and transformed into concrete curving spaces by the assistance of wire-frame.

In addition, a number of critical issues on generative architecture are explored in the three design experiments. They are (1) the concept and logic underlying the methodology of design generation; (2) the formulation of the generative design systems utilizing the existing morphological structures, ranging from the individual architectural elements to the integral urban forms; (3) the employment of the digital design media (e.g. image processing, 3D abstraction and extrusion) for various purposes during the process of analysis and generation. As exemplified in the first design experiments, "differential generation" and "differential transformation" constitute the key concept for the methodology. In the second experiment, the notion of "infra-surface" is posed. In the third experiment, architectural design is seen as an integral whole which has to do with three levels of urban landforms. Following that, a systematic procedure has to be developed. In the three experiments, existing morphological structures are employed as the point of departure. Thus, it is necessary to establish a strategy for analysing the existing structures and a mechanism for generating new designs. Finally, the digital design media are powerful in form generation and real-time operation. Nevertheless, it is suggested that the media be guided by thoughtful design concept and procedure. The latter two, in the case of this study, come from the deep understanding about and creative deduction from the existing morphological structures.

Acknowledgement

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