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Computer Integrated Design:
Transformation as Process

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Introduction

"The search is what everyone would undertake if he were not stuck in the everydayness of his own life. To be aware of the possibility of the search is to he onto something. Not to he onto something is to be in despair." [1]

To bring together poetry, magic and science, to explore beyond preconceptions, to invent spaces and forms which re-form and inform man's experience, these are the possibilities of architecture. Computer integrated design offers a means for extending the search, one which integrates both conceptual and perceptual issues in the making of architecture. The computer may assist in generating constructs which would not have been created by conventional methods.

The application of computer techniques to design has to date been focused primarily on production aspects, an area which is already highly organizable and communicable. In conceptual and perceptual aspects of design, computer techniques remain underdeveloped. Since the impetus for the development of computer applications has come from the immediate economics of practice rather than a theoretically based strategy, computer-aided design is currently biased toward the replication of conventional techniques rather than the exploration of new potentials.

Over the last two years we have been involved in experimentation with methodologies which engage the computer in formative explorations of the design idea. Work produced from investigations by 4th and 5th year undergraduate students in computer integrated design studios that we have been

teaching at the University of Southern California demonstrates the potential for the use of the computer as a principal tool in the exploration of syntax and perception, space and program. The challenge is to approach the making of architecture as an innovative act, one which does not rely on preconceived notions of design.

Design Methodology

Transformation
In the frontispiece of the story 'The Library of Babel", Jorge Luis Borges wrote, "By this art you may contemplate the variation of the 23 letters.[2] In the library of Borges, the alphabet provides language with a set of characters from which an unlimited number of texts may be randomly generated. For the designer, the number of available elements or geometries are infinite; as well, there is no lexicon of prescribed forms. The analogy of architecture to language, while perhaps powerful as metaphor, creates difficulty as the problem of meaning is confronted. The designer is faced, at each step in the process, with a number of options which may be selected or directions which may be chosen. Transformation as process, applied to any given form or formal structure, generates open-ended variations. The integration of the computer into the design process expands the opportunity to explore options, but, as well, helps to identify and categorize them, enabling the formation of constructs that would have remained unseen without it. Figure 1 illustrates a series of transformations which have as their origin Philip Johnson's Glass House, developed by a student who had documented and analyzed the work. In this exploration, architectural elements are loosened from their Platonic confinement and unpinned from the modernist grid. As in the labyrinthine library of Borges, the computer poses a framework which may be engaged to assist in the generation through combination and transformation of an unlimited set of possible project structures. These structures are made as syntactic patterns or diagrams, empty of architectonic content.

Order
Juxtaposed to this infinitely extended process of design through transformation is the notion of inherent order. Michel Foucault described order as that which

"at one and the same time... is given in things as their inner law, the hidden network that determines the way they confront one another, and that which has no existence except in the grid created by a glance, an examination, a language, and it is only in the blank spaces of this grid that order manifests itself in depth as though already there, waiting in silence for the moment of its expression." [3]

It is the search for order that brings purpose to the formation of a design. In architecture, the process of design generation is overlaid with a matrix of intentions or rules, formed by the designer in response to project requirements or hypotheses, which enable the designer to make decisions while allowing experimentation with a range of alternatives. The formulation and testing of a hypothesis and the imposition of architectonic intention differentiates the design process from formal pattern making. The hidden order in the world referred to by Foucault is not singular or simply definable, not static or representable as a whole. In architecture, ordering systems may exist simultaneously, each overlaid to establish its domain, in combinations which are simple or complex, complete or unfinished, aligned or chaotic.

Code

As the seasons passed and his missions continued, Marco mastered the Tartar language and the national idioms and tribal dialects. Now his accounts were the most precise and detailed that the Great Kahn could wish and there was no question or curiosity which they did not satisfy. And yet each piece of information about a place recalled to the emperor's mind that first gesture or object with which Marco had designated the place. The new fact received a meaning from that emblem and also added to the emblem a new meaning. Perhaps, Kublai thought, the empire is nothing but a zodiac of the mind's phantasms.

"On the day when I know all the emblems," he asked Marco, "shall I he able to possess my empire, at last?"

"And the Venetian answered: "Sire, do not believe it. On that day you will be an emblem among emblems."[4]

As Marco Polo designates a gesture as an emblem to denote a generative idea, the coding of essence or underlying order opens it to the receipt of other information. Design intention is encrypted into emblematic diagrams, the form and structure of which implies the formation of a particular project program. The forms which encode the project become the repository of meaning which goes beyond functional requirements. The designer seeks an essence, an underlying order, and, giving it specificity, brings the project to the surface. The emblem implies function and directs development in the work. In this elusive realm lies a domain for experimentation.
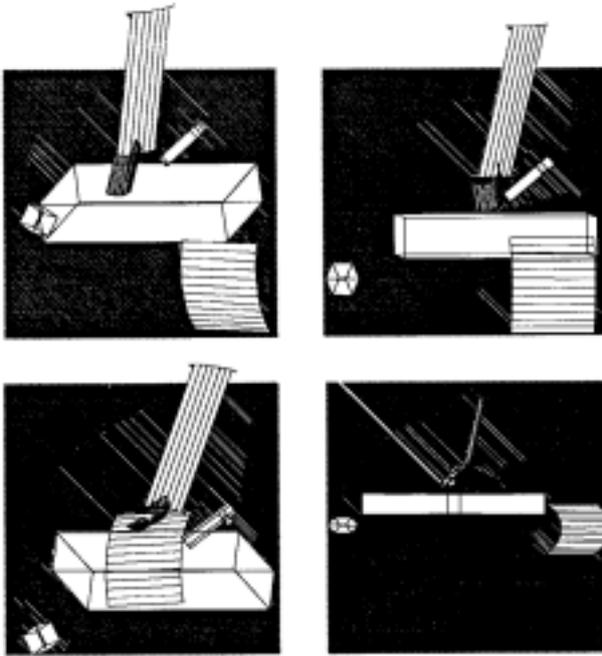
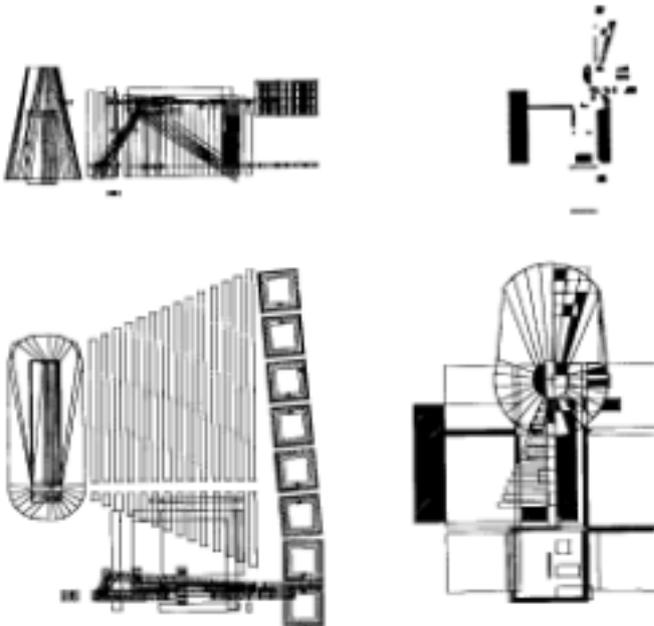Figure 1 YMCA transformation (Nazneen Cooper)

Figure 2 Single parent housing model (Andrew Wong)

Abstraction

The quantity of things that could be read in a little piece of smooth and empty wood overwhelmed Kublai; Polo was already talking about ebony forests, about rafts laden withlogs that come down the rivers, of docks, of women at the windows...[5]

The information that Marco Polo can interpret from looking at a chessboard of inlaid wood parallels the information potentially derived from a designer's reading of a diagrammatic image. The reading of syntax embedded in drawings of an architectural project may be seen as precedent, not in a literal sense of an immediately accessible representation, but as a response to a set of abstract relationships or traces which embody the path of culture and experience and, by extension, the history of architecture. In figure 2, a series of analytical transformations, which began with the documentation and analysis of Aldo Rossi's Cemetery at Modena and Andrea Palladio's Invention LIII from the Second Book of Architecture, generates a self referential construct which was later interpreted as an emblem for single-parent housing, day care and workshops.

   Abstraction is applied not only to formal syntax but also to the essential architectural issues of program, site, and tectonics. Design is an interactive process which moves between conceptual and perceptual issues. A conceptual idea is tested and explored through a series of perceptual transformations; conceptual issues are then reformulated and new perceptions of those ideas are explored. Possibilities, variations and aspects emerge, and new perceptions evolve the concepts. Figure 3 illustrates a sequence whereby a section, derived from a sequence transforming the form of John Hejduk's Bye House to that of Le Corbusier's Salvation Army Hostel, was reconceived as a plan diagram for an urban nunnery. Interpretation of program, of the nun's dual need for extension into the community and contraction into a private world of faith, guided the transformation of the initial construct into a plan diagram of program organization. The reading of intention or function from abstract forms gives form life, creating a dialogue between the intentions of its maker and the implications for a solution.

Computer Integrated Design

Abstraction and the Computer
The more a design problem may be stated in abstract and conceptual terms, the more readily it may be manipulated within the medium of the computer. To integrate the computer into design in a substantial way, it is essential to use it at the earliest stages of design conception. Understood as a tool for design
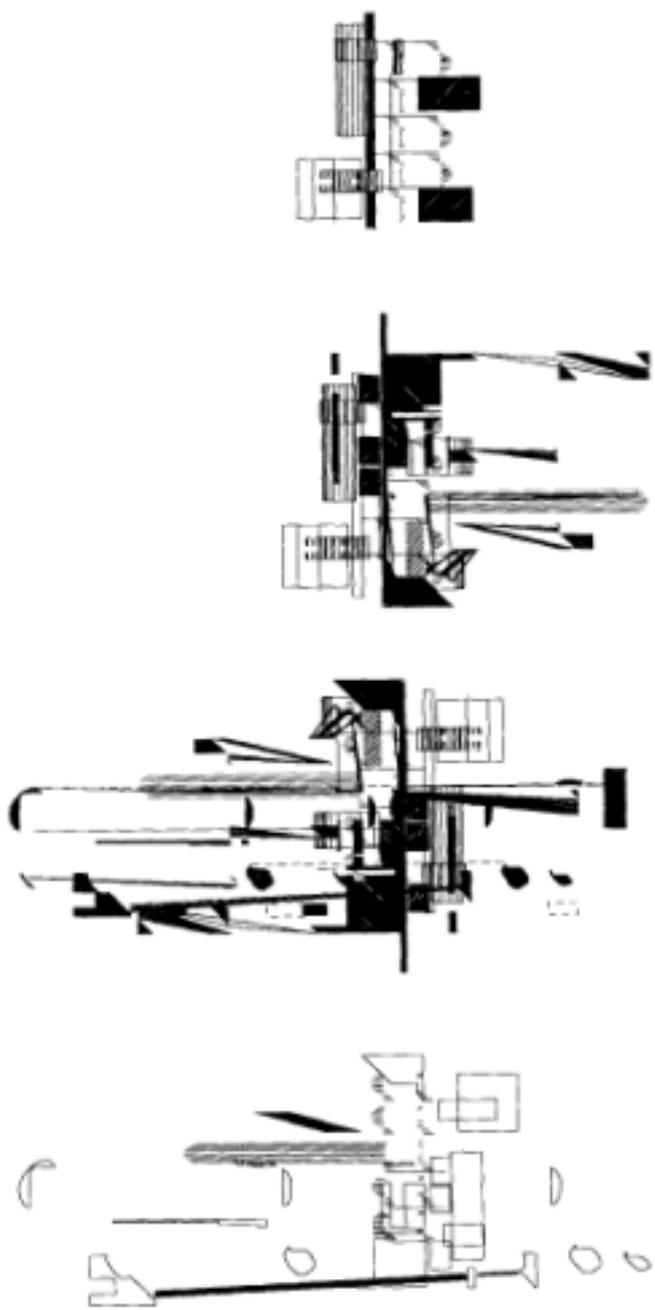
Figure 3 Nunnery program model (Elisabeth Leung)

experimentation, the computer facilitates the manipulation of formal syntax or spatial systems to generate a series of alternatives through a process of critical intention, evaluation, and transformation. The integration of the computer into the design process places the syntactic structure of its program next to that of the architectural project; the parallel conceptual structure of the computer program will impact the conceptual structure of the design project.

Computer Syntax
Each aspect of an architectural project, such as program, site, or load bearing structure, has an underlying syntax. Similarly, computers and computer programs are ordered according to a logic and set of rules which establish a syntax for the type, structure and sequence of operations that may be performed. The syntactic structure of the computer poses a framework for design which may be manipulated to generate an almost limitless set of possible project structures within a given domain. These structures are seen as syntactic patterns or diagrams, empty of architectonic content. A matrix of rules, structured by project intentions or hypotheses, overlays the process of transformational generation; the designer makes decisions while experimenting with alternatives within a critical framework. The formulation and testing of hypotheses or the imposition of architectonic intention differentiates the design process from pattern making. The reading of formal intention from figural or emblematic diagrams establishes the threshold for design process.

   The imposed order of the computer environment necessitates critical thinking in the development of both project intentions and architectural systems. A tendency to consider only a few design options is displaced by an ability to readily explore a wide range of potential options through a process of transformation. In Figure 4 a series of alternatives was generated; the student used, as precedent, documentation drawings of Palladios Villa Pisani and Villa Thiene. Computer supported design enables the designer to rapidly generate a serial progression of two- and three-dimensional studies as solid or planar models, wire frame or line drawings, orthographic or projected views, which explore the potential of the design. The computer medium itself acts to change perception, enabling experimentation with formal and spatial alternatives that would be too difficult or time consuming to represent through conventional techniques. The ability to design in perspective and to design simultaneously in two and three dimensions in a continuous process, transforms the process itself.
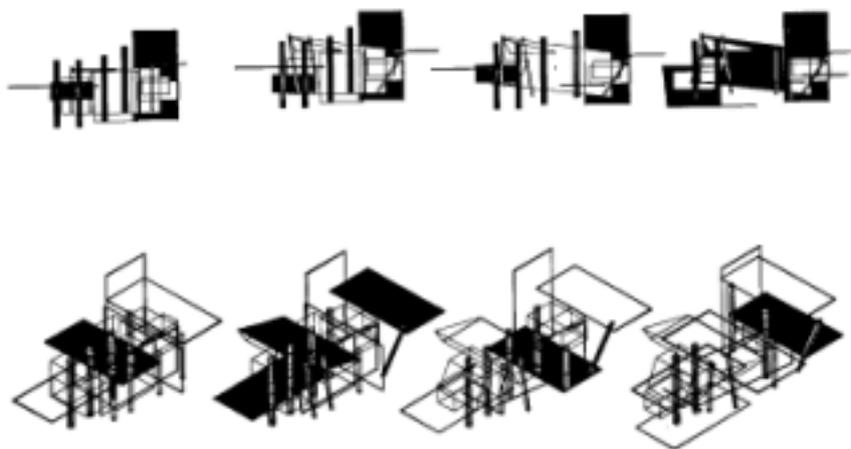
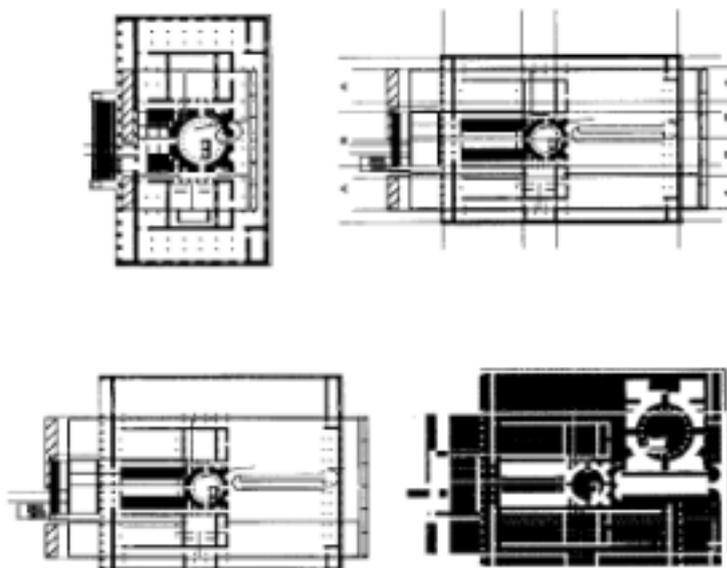Figure 4 Urban oasis housing model (Anita To)

Figure 5 Urban design transformation (Maria Baldenegro)

Conventions and Representation

The particular form or spatial configuration that an architectural proposal may take is directly connected to the conventions by which it is represented. Architectural conventions, such as the plan, section, axonometric or perspective drawing, have specific implications for the design product. The means and techniques utilized to represent architectural work, whether ink line drawings, watercolor washes, or white cardboard or unpainted wood models, also critically effect the message and the perception of the work. Similarly, the computer is not a neutral medium. It can be used to develop techniques for analysis and design, establishing new conventions for representation and expanding the bounds of perception of space, form and design process.

The stereotypical expectation of the computer-generated image carries implied or anticipated precision. From the first image produced, an autonomous and absolute reading is conveyed. This precision can inhibit exploration with 'sketch' studies, through which fundamental ideas evolve before details are resolved. As computer techniques are applied to design, awareness and control of the drawing intent is critical. One way that the computer medium imposes itself on the process is in the designer's tendency to organize elements as autonomous objects within the file structure of the computer environment. Reforming project files or superimposing new spatial readings may break organizational boundaries imposed by the information structure developed in the initial stages of design.

Computer drawing should not necessarily be directed to the replication of conventional techniques. Computer techniques include solid models, three dimensional x-ray drawing, animation, video overlay, and simultaneous orthographic and perspective projections. These techniques expand the designer's ability to visualize the design and extend perception, investigate the implications of decisions, and allow a more fluid process of project development as design information is manipulated.

The Design Studio

Curriculum

The intent of the studio curriculum is to describe a method for animating the design process, to reveal ordering principles embedded in the work, and to support and direct the making of architectural form. The aim of this methodology is to explore, invent, simulate a process of making architecture according to the rules of its own discourse. The design curriculum is structured according to a sequence which begins with abstract studies and proceeds to more concrete considerations.
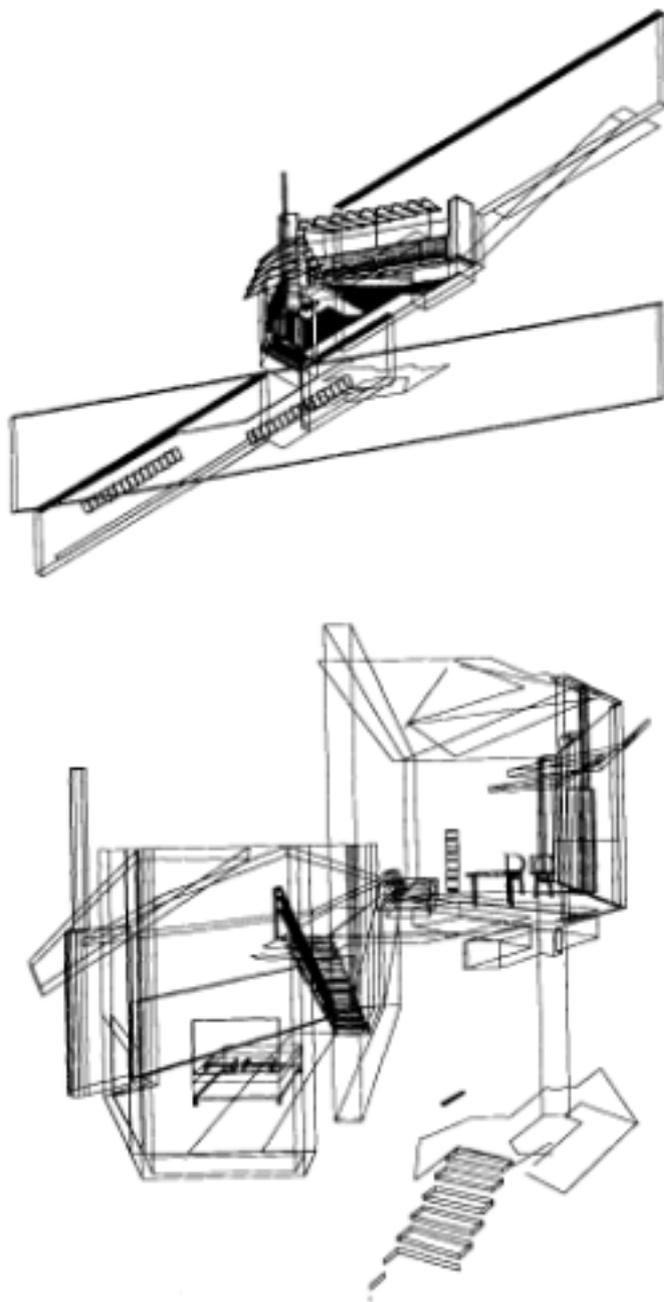
Figure 6 Los Angeles house (Sammy Wong)

Documentation & Analysis

The fundamentals of computer integrated design are taught through a series of exercises in which each student documents an assigned existing work of architecture entirely with the computer using Point Line software. In the exercise students are expected to go beyond merely replicating existing documentation to explore the work analytically. Critical analysis is therefore understood as an essential component of the design process from the outset. Computer techniques are explored as they support ideas discovered in the work. A wide variety of representational formats are explored.

Syntactic Transformation

Existing architectural works studied in the documentation phase are decomposed and transformed according to rules inherent in their order to explore alternative configurations. Alternative ordering systems may be superimposed. These exercises illustrate the power of the transformational process and develop notational conventions for representing perceived ordering structures and architectonic configurations. In Figure 5 a series of analytical transformations pairs diagrams of Schinkel's Altes Museum and Le Corbusier's Millowners Association and performs operations to overlay, stretch, expand, and invert them, in response to a desired set of syntactic relationships.

The first exercises are open-ended; a series of suggested operations as defined by the computer program are explored. In subsequent exercises each student develops a series of transformations directed by a set of project rules or intentions which they have established. The framework of the assigned building may form the syntactic structure of the work, or the introduction of a second building or second syntactic structure may overlay, combine or transform the initial project.

Context Formation

The formation of a design solution must confront the definition of the problem to be solved, the domain to be engaged, and the actions to be taken. The formation of the problem context is a direct statement of the cultural, ecological and technological context in which the specific program and site are situated.

The Chinese philosopher, Laotse, is credited with saying: "Doors and windows are cut out of the walls of a house, but the ultimate use of a house depends on the parts where nothing exists." A design solution is formed from within, considering variables of project scenario and program definition; the range of human actions which the designer considers is established. Relationships established between parts of the program form a model of program syntax, which represents ideas about hierarchy and function, human

needs and aspirations, the transmission of ideas and ways of living, and considerations of the culture of the place and the culture of architecture.

A site is understood to have a context in both the physical realm of place and the conceptual one of culture. The rhythms of time and history are evaluated. An analysis of existing, pre-existing, and projected site conditions leads to development of a model of site syntax, establishing relationships intrinsic to place.

Project Synthesis

Models of program and site syntax are overlaid to create a new order, a composite context model, while maintaining fundamental relationships to the syntactic structures developed in the previous steps. The process is synthesized, and the design is made specific; the project is placed within its site. Technological considerations, physical dimensions as a result of functional requirements, spatial objectives, and the tectonics of building systems (building materials, construction techniques, structural systems) are overlaid and developed as an integral part of the architectural idea. Figure 6 shows a projection and an interior x-ray projection of a Los Angeles House. At this point in a projects development, the initial architectural precedents are not apparent at the surface, but traces derived from transformation of those precedents are embedded in the new project. Spatial studies designed with three dimensional computer models depict relationships at an experiential scale.

Conclusion

The medium of the computer enables a change in process and perception which has the potential to alter spatial or formal understanding of the making of architecture as powerfully as did the idea of perspective in the Renaissance. As the Renaissance concept of perspective construction, understood as technique, altered the relationship between the conventions for representation of buildings and their physical manifestation, techniques inherent in computer integrated design establish new dimensions in design exploration, which may be grafted onto conventional understanding.

The abstract yet complete nature of a computer sketch enables it to exist both as the representation of an idea and as an artifact, existing apart from the set of intentions which caused it to be made. It is able to be retrieved, reproduced or transformed as information in a data base. The computer medium expands both the domain of experimentation and the potential for generating

design alternatives. In seeking a model for computer-integrated design, we speculate on a process which extends the dialogue between form, program, and culture towards the making of a new architecture.

The catalogue of forms is endless: until every shape has found its city, new cities will continue to he horn. When the forms exhaust their variety and come apart, the end of cities begins. In the last pages of the atlas there is an outpouring of networks without beginning or end, cities in the shape of Los Angeles, in the shape of Kyoto-Osaka, without shape. [6]

Notes

1   Percy, Walker. The Moviegoer.

2   Borges, Jorge Luis. The Anatomy of Melancholy, "The Library of Babel", Labyrinths.

3   Foucault, Michel, The Order of Things.

4   Calvino, Italo. Invisible Cities.

5   Calvino, Italo. Invisible Cities.

6   Calvino, Italo. Invisible Cities.