Alexandria University
Faculty of Fine Arts
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"Impact of The Digital Simulation And the Dynamic References On The Form Methodology"

A Thesis submitted to the faculty of Fine Arts in partial fulfillment to the requirements of the
Doctoral degree of Science in Architecture.

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بسم الله الرحمن الرحيم

"وما أوتيتم من العلم إلا قليلا"

صدق الله العظيم

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The Researcher

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Introduction

Every architectural design process starts with the schematic design phase, wherein architects have to satisfy a collection of adjacency constraints among spaces and dimensional constraints over each space element. Here, architects face a complicated problem. Some constraints contradict others; priorities may not be clear and the adjacency constraints grow exponentially as the number of rooms in a design problem increases. In large design problems, optimizing such a problem is a time consuming trial-and-error task that could benefit from computational assistance.

On the other side; the computer by the end of the 20th century and the beginning of the 21st century has a great impact on the architecture, not only as a modeling tool (chapter 1-1) but also as a design tool. The computational design tools for spatial layout planning present perhaps the most comprehensive challenges in the area of architectural design computation. Spatial design tools are the common ground where design representation, generation, evaluation and decision-making are required to be addressed simultaneously for the goal of realizing meaningful design exploration tools. Additionally, a multitude of ill-posed design intentions, non-explicit goals, and the non-deterministic nature of the design process itself add to the problem complexity. Given the difficulties, the problem of architectural layout design continues to challenge researchers from all areas of design computation.

Architectural design process involves a mix of quantifiable and subjective goals, preferences and constraints. Aesthetic preferences and other subjective aspects of designs are typically ignored in automated models because these aspects are difficult to model with mathematics. Designers generally explore subjective aspects during the conceptual design phase by sketching and comparing design alternatives. Very few CAD packages address the needs of designers during this initial conceptual exploratory phase of design.

But this brings us to the question; can the computer be creative? Few CAD packages that satisfy the needs of the designer, then is there any method or software that can help the architect in the process of the design itself? And the answer which will be found in chapter 1-2 is yes.

Researchers have used several problem representations and solution techniques to describe and solve the problem. Among those techniques and methods that have been used in optimization problems, generative algorithm method have shown a potential to produce novel optimized solutions.

In this thesis, genetic algorithm, one of the powerful search methods in artificial intelligence, is used to create an intelligent prototype to be used in early phases of design. This prototype is able to generate alternative schematic designs to help the architects choose a direction for their design, while having a broad perspective about other good possibilities. It’s an alternative automated layout method that generates goal-directed design alternatives given a set of design objectives and constraints. It presents a novel interactive design tool that uses optimization to help the designer quickly

generate and compare designs using visual and computational feedback to understand design trade-offs.

To apply this prototype and to discover the ability of the computer to generate forms, a design model of a home has been chosen to apply this method. Because of that the relation between the spaces of the home definitely helps implementing those roles. This relation is clear and can be easily defined for most of the architects, designing of the home and understanding the space relations could be considered the basic and first step for any architect who is going to work in the field of architecture.

Also the home design could be considered one of the more effective projects in which the mass customization can be applied. Here, the programming of computer application that can join between the architectural design and generative algorithm would be more beneficial. This computer application can also help the architects generates a typical model to satisfy the requirements of a broad number of customers, then the model can be transferred from the design phase to the production phase through the different architectural processes.

This thesis is focus on the approaches of the generative design, the programming of this computer application, and how we can make use of the different fields of science to serve our filed of architecture, finally the validation of this computer application will be shown, also the limitation of the software and expectations will be discussed.

Chapter 1-1

Digital Architecture Categorization

1.1.1 Introduction

Currently, the information era is rapidly transforming, and implanting different trends in many fields of life. This Gradual computer implementation into everyday routines has developed many digital technologies. One of these new trends is 3-Dimentional computational concept, which helps calculating many volumetric parameters that are too complex for the human brain to fully envision. This new trend is increasingly influencing the field of architecture.

The computer, then, will no longer be merely a production, engineering or facilitation tool under the command of the architect-user but a generating entity with its own virtual intelligence or "knowledge" of the design process; the computer will function as a partner. Architecture also is becoming a computational collaborative art based on the choreography of robotic manufacturing, while the architect, freed from the need to continuously invent a new, is becoming more like a choreographer of space and material production.

So, Mixing information and data with architecture has been found very contrasting. Most attempts of synthesizing a rational field with a humanistic art were heavily criticized. In spite of this criticism, it is clear that digital technologies have effect on the architectural field as it does to any other.

This chapter compares the different categorizations of these digital approaches, for the architects who fuse the computer's techniques into their working methods in a more efficient or exploratory way, in terms of the design process, as well as on the levels of organization and experience, the architects will be organized into a detailed categorization.

1.1.2 Definition of the Digital Architecture

Due to the digital revolution a new architectural terminology has been developed, such as “Digital Architecture”, which is not yet technically accepted. This trend is known as an experimental trend that is seeking new possibilities and methods. While only a very few actual buildings in this genre exist, and several of them are definitely visionary in character. Many designs have been rejected by selection committees or timid clients who fear of the expense, and have thus been relegated to that limbo of “pure” architectural fantasy where unbuilt projects are unjustifiably forgotten. This despite the fact that the field of media architecture provides an opportunity for wide-ranging innovation.

To make it clear and sharp, the term “Digital Architecture” can be defined as an experimental approach which is blending novel "hard" (construction and materiality) and "soft" (digital technologies) to breed an architecture of incorporation and conjunction, creating potential forms which are made possibly through computer programming and application[1].

Architecture in the beginning of the 21st century should be understood as an "electronic technical art." based less in the representation of ideal forms than in the scripting of machining codes and routines for numerically controlled (CNC [2], lasers and water jets). Also he suggests that the calculation of space, form and structure will usurp design altogether and eclipse the architect's previously deterministic role.

[1] Researcher.

[2] Computer numerical control (CNC) is a computer "controller" that reads G-code and M-code commands and drives a machine cutting tool, a powered mechanical device typically used to fabricate components by the selective removal of material. CNC numerically interpolates the points along a cutting tool's toolpath and directs the servomechanisms that translate the data into movement.

1.1.3. Categorization of the Digital Architecture approaches:

Many of the digital architectural pioneers tried to categorize the different approaches of this new trend. This study will show these different categorizations. So, two spectrum of these categorized approaches will be presented, for the architects who fuse the computer's techniques into their working methods in a more efficient or exploratory way, the different between the two classification is that Kipness has categorized the digital architecture due to the output product, while Kolarevic has categorized it due to the design conceptual process[1].

1.1.4. First Categorization; Kipness J. hypothesis[2]

Kipness thought of digital architecture as a global term is divided into two trends[3]; deformation and information. The deformation trend, deals with manipulating and deforming an existing form. This deformation may be a result of the clients needs, architectural philosophies, or natural and mathematical phenomenon. These deformations could be driven according to natural forces allowing it to be suitable for construction.

On the other hand, the information trend is concerned with the open form, or the form that is not stationary and always changing. He called it the "Unfinished Form". Such forms usually are experimental forms that depend on variable changing (such as Para Cube- M.Novak figure 1.1.11). Due to the technological limitations of construction they are hard to build in real life, however they could be used as virtual spaces.

1.1.4.1 Architectural (De-formation)

The characteristics of external forces (tension and deformation) resulting in continuous curvilinear soft systems and transforming existing spatial qualities through smooth affiliations. Relationships with the site are undetermined and unexpected since they do not emphasize a prevailing architectural language, typology or material. Instead, as Kipness argues, they amplify characteristics hidden in the site and generate a coherent incongruity.

Therefore, this smooth and continuous mixture can produce a homogeneous architectural form that has the essentially soft, and flexibly curved layout. The computational process is a

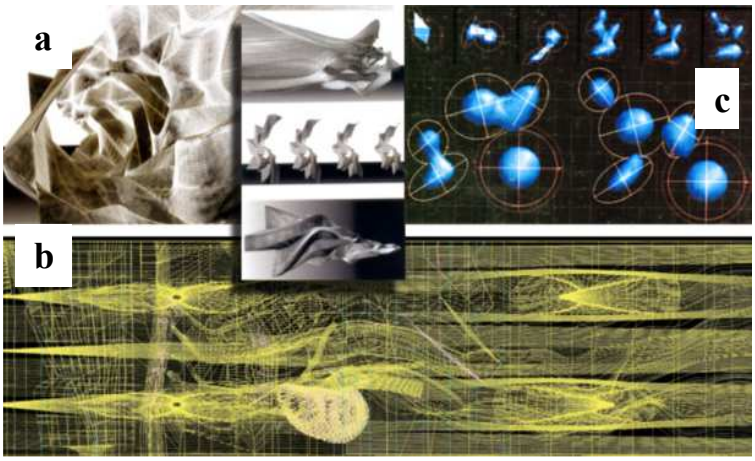

Fig (1.1.1) Deformation forms

a: model space deformed system, phylux. Karl Chu. 1999
b: blobs strategy, the concept of New York Presbyterian Church 2000
c: deformed surface of Kansay Library competition 2000
Source: Chirstian Pongratz and Rita Perbellini,Maria "Natural Born Caadesigners: Young American Architecture"; Brikhauser,Basel, 2000. P:52

[1] Researcher

[2] **Kipness hypothesis**: Jeffrey Kipness is an urban designer as well as a curator and critic of architecture. He is currently the curator of Architecture and Design at the Wexner Center for the Arts, and professor of architecture at Ohio State University.

[3] Chirstian Pongratz and Rita Perbellini,Maria "Natural Born Caadesigners: Young American Architecture"; Brikhauser,Basel, 2000. P:52