Timing and spacing in Architecture

Architecture with motion

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It is a fact that the Animation and architecture have common and strong bonds in various forms. According to animators, and architects as well, there are two main and vital concepts which are the basics of animation, these are Timing and Spacing. The paper represents an analogy between animation and architecture focusing on these two concepts. So, in the following sections we discover the relation between animation and deforming geometry in architecture. By looking through the history and theory of architecture we find many architects' attempts to apply animation as a concept within their forms. This paper will review what pioneers have achieved in designing through animation. At the end of the paper a case study is being analyzed by showing how the concept of animation is applied to an existing building due to the research's main points.

Keywords: Architecture, animation, timing, spacing

INTRODUCTION

As previously mentioned in Ching's book "Architecture: Form, Space, and Order" the basics of form and how they developed in an animated process. Ching (2008) have mentioned that Point, Line, Plane, and Volume are the basic design elements; when we animate points we get lines, when we animate lines we get Planes, and consequently when planes are animated we get volumes as shown in (Figure 1). Animation as a discipline relates transformation of form over time. Everything around us is moving or deforming during a certain time segment. When we look in natural and artificial systems as shown in (Figure 2), we find an animation and different state every second. A lot of contemporary designers used the concept of animation to express their forms. The variations resulted from different methods of applying the concept of animation to deform geometry. In addition to the cutting edge tools that are included into animation software's, these tools can be used to help designers to achieve their goal with the final result and help in evaluating and selecting the best results. This paper is a trial to include some animation theories to get fast, flexible, and handy results with geometry deformation.

Figure 1
animation of design elements (Ching, 2008)
ANIMATION IN ARCHITECTURE FORMS

From the very basics of design elements to the sophisticated Architectural Forms; architects have tried to apply animation in different works. First we should explain more about animation meaning. Artistically, Animation is the process of creating a continuous motion and shape change illusion by means of the rapid display of a sequence of static images that minimally differ from each other. Animation is a term that differs from, but is often confused with, motion. Where motion implies movement and action, animation suggests animalism, evolution, growth, actuation, and vitality. Many theories had explained the animation process especially the twelve principles of animation that are established by Walt Disney as being declared in the following section.

The Twelve principles of animation

Timing and spacing are two of the twelve animation principles that have been established by Walt Disney, and the nine old men at Disney studios. These principles are squash and stretch, anticipation, staging, straight ahead and pose to pose animation, follow through and overlapping action, slow-out and slow-in arcs, secondary action, spacing with timing, exaggeration, solid drawing and appeal [1]. These principles helped to achieve believable looking cartoons, and still working until nowadays. Timing means how long it takes something to happen or not happen; which means different actions can happen or stay at the same action for a determined time, while Spacing is Frame by Frame displacement of the moving elements within a certain time as shown in (Figure 3); and that describes the movement whether it is at the same speed or slow at the beginning or in the middle, or in the ending of the time amount given to that movement, but how animation principles can be applied to Architectural forms. “To terms of magnitude, and of direction, must we refer all our conceptions of Form. For the form of an object is defined when we know its magnitude, actual or relative, in various directions; and Growth involves the same conceptions of magnitude and direction, related to the further concept, or ‘dimension’, of Time”. (Thompson, 1917, 1961, p. 15.).

FRAMEWORK

Animation software platforms provide a number of tools that enable controlling the change of form by the time, they incorporate three basic elements:

• A time keeping tool.

• Transformation tools.

• Control tool

Since Motion implies movement and actions. There are many words written about the motion in Architecture. Giedeon, Ferstegen, Jomakka, Lynn try to describe, and classify the relation between motion, and architecture (Gorczyca, 2013). Motion is considered...
to be one of the important factors of contemporary ways of expression in architecture. Motion can be expressed in architecture in two ways (Lynn, 1998), First way is static; it is based upon fixed relationship between functional program and the user. Multiplication and sequencing of static frames is used to introduce the idea of "Dynamic Architecture". Second way is dynamic, and it resists the separation of form from its animating forces. Form is perceived in a space of virtual movement and force rather than within an ideal equilibrium space. Instead of a fixed prototype, flexible models are created; which rather a potential of mutable variables. This concluding what is named as "performance envelop". A shift in technology is necessary to achieve that, but also it requires a shift in sensibility from reduction to combination to compose time based topological designs. In the 20th century early works architects used some methods to express movements like: inclined planes, acceleration of facade rhythm, and aerodynamic curves. Those methods remained almost unchanged, but expanded according to technology development to come up with buildings that animate themselves, and interactively respond to user needs. Applying the concept of Timing and Spacing gives the designer the ability to reshape animation, and deformation sequence along the building.

**ANIMATED FORMS BY ARCHITECTURE PIONEERS**

Many architects have applied animation concepts to their Forms; for instance Siegfried Gideon's Mechanization takes Command and Space, Time, and Architecture that established the relationship between Architecture and time; that worked as the primary concern of twentieth Century Architectural theory and design. Le Corbusier also tried to lift his buildings above the ground to allow the natural nature continuity, and used animation with opening sizes and light sources. Frank Lloyd Wright in Guggenheim animated the circulation and we can notice the reflections of the circulation on the Form of the museum. Spirals are a beautiful shape; they have marvelous curves and convey energy and motion as shown in (Figure 4). Not only that, they are a truly efficient form used in nature, and we see them so many places in our everyday lives. Frank Gehry, Zaha Hadid, and Greg Lynn have their own applications of animation on Architectural forms. Greg Lynn Sees the thing that makes animate geometry so exciting and problematic to architecture is that it is the last discipline to incorporate an ethics of motion into its thinking.

There are two methods for the modeling of movement in architecture; the first involves Procession, and the second involves Superimposition. The
processional method has two alternatives; the first is the idea that Giedeon developed that makes the time is built into form as memory. The second model is associated with Colin Rowe in his text Transparency: Literal and phenomenal, the literal transparency meant amount of translucency that the material has; hence the phenomenal transparency is imprinting deeper formal space on surface, phenomenal time may include "shearing", "Rotating", and "shifting" operations. Animation is based on non-linear, dynamic motion techniques; motion here is defined by interacting vectors that unfold in time. Contemporary Animation uses interacting forces and vectors within an open temporal sequence rather than sequences of key frames. Form can be conceived in a space of virtual forces rather than within an ideal equilibrium space of stasis. For example discrete point coordinates define an object in ideal static space. The trajectory relative to other objects, forces, fields, and flows defines an object immersed in an active space of forces, the modeling of architecture in a field populated by forces and motion is dependent on the development from previous theory of stasis. Many architects have critiqued static models, such as processional sequencing. "Statics does not hold an essential grip on architectural thinking as much as it is a lazy habit or default that architects either choose to reinforce or contradict for lack of a better model" (Lynn, 1998). Performance envelope By modeling the potential of multiple variables as what is often referred to as a "performance envelope" a series of possibilities can be designed from which particular configurations are "instanced". Similarly, multiple independent interacting variables can be linked to influence one another through logical expressions. Expressions are statements that define the size, position, rotation, direction or speed of an object will by looking to other objects for their characteristics. Suggested Timing can control the length of expressions or statements affected by force fields. Timing also can describe the time in which geometry is being subjected to different kinds of forces, can also defines the weight of an object. Timing plays an essential role in illustrating the emotional state of an object; it is the varying speed of the movements. Spacing is the strength of the effect of expressions or statements; it could happen evenly; for example when a cluster from the form is shifted along one axis by evenly distributed force, or according to a certain weight map that controls the strength of force effects; it worked as a filter.

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RIGGING THE BUILDING

Rigging is a commonly used term by CG character animators, and designers. Rigging is meant to be the corner stone between the idea that creates the character, and the final attitude of the character with all its personality aspects as shown in (figure 5). Within the sketch and concept, and the final result behavior, It simply consists of main three stages:
1. Creating a bone system.

2. (Enveloping or skinning) linking bones to the skin or outer surface.

3. Creating special controls, and sliders to make it easy while animating, and deforming.

**Characteristics before rigging**
In characters it is easy to know where to put joints as we already know their placement in the original character. In buildings joints will represent the primary major action, and deformation; this can be change of direction horizontally, or vertically, it could be change of expression language, or even change of materials.

**Enveloping the rig**
Enveloping or skinning the rig is simply linking the bone system to the surface of geometry. In this stage the interaction between bone system and geometry is defined.

**Adding Controls**
To automate and simplify the actions and reactions of for the building, special controls is added. These controllers will help the designer to apply (The Timing and Spacing sliders) to decide the placement of deformer or action, and the density of the effect upon the geometry.

**CASE STUDY**
This is a presentation about the parametric setup of LAVA's Snowflake tower. The parametric definition is based on the concept of a "Snowflake". The Model allowed designers to tweak the tower design on both micro and macro scale. Apart of just studying the width of balconies or radius of the core, they were also able to generate completely different shapes as shown in (Figure 6).

The snowflake geometry was interpreted as shapes with a fractal nature of edges as shown in the following (Figure 7). The complete model is controlled by eight typical snowflake configurations, with a specific on a central spine. The central spine defines the height of the tower, the number of floors, and the floor height as shown in (Figure 6). Due to our hypothesis: The vertical spine represents the bone system, or the creation structure. In this case we have one bone for the spine, if we intended to twist the tower we should have added more bones. The snowflake section represents the plan unit as shown in (Figures 8).
The core of parametric modeling is the definition of basic plan unit, and the deformers that affect the plan unit. Skinning stage in the case of snowflakes tower will be regular, but with a curvilinear nature as shown in (Figures 9,10).

Seven control parameters permits to generate a wide range of plan shape variations. This is the start of the 3rd stage rigging for the tower. These are the sliders, or controls that will generate the final result. For example (p1, p2) are the balcony positions, while (r1, r2) are the balcony radius, and (e1, e2, e3) are the extension for balconies as shown in (Figure 11). It shows the different results we can achieve by changing the parameters along the spine. So that we have the same spine, the same plan, with a number of deformers, and parameters but with different variations and different stages of animation. Due to Timing and Spacing sliders are made for each parameter to control the position of each parameter (timing), and to describe the change of shapes along the spine (spacing).

CONCLUSION
Timing and spacing can be applied to architecture to produce new strategies for deforming and manipulating architectural geometry in a sophisticated manner. Timing can control the change of Forces that occurs to the geometry, while Spacing can be applied in two different models:

1. Control the weight of deformations upon certain cluster of the geometry deciding points of high density, and points of low density; and this is similar to its effect on animation.

2. Spacing can apply different deformations to different spaces according to their functions.
or placement or any other variables can the
designer make as an input.

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