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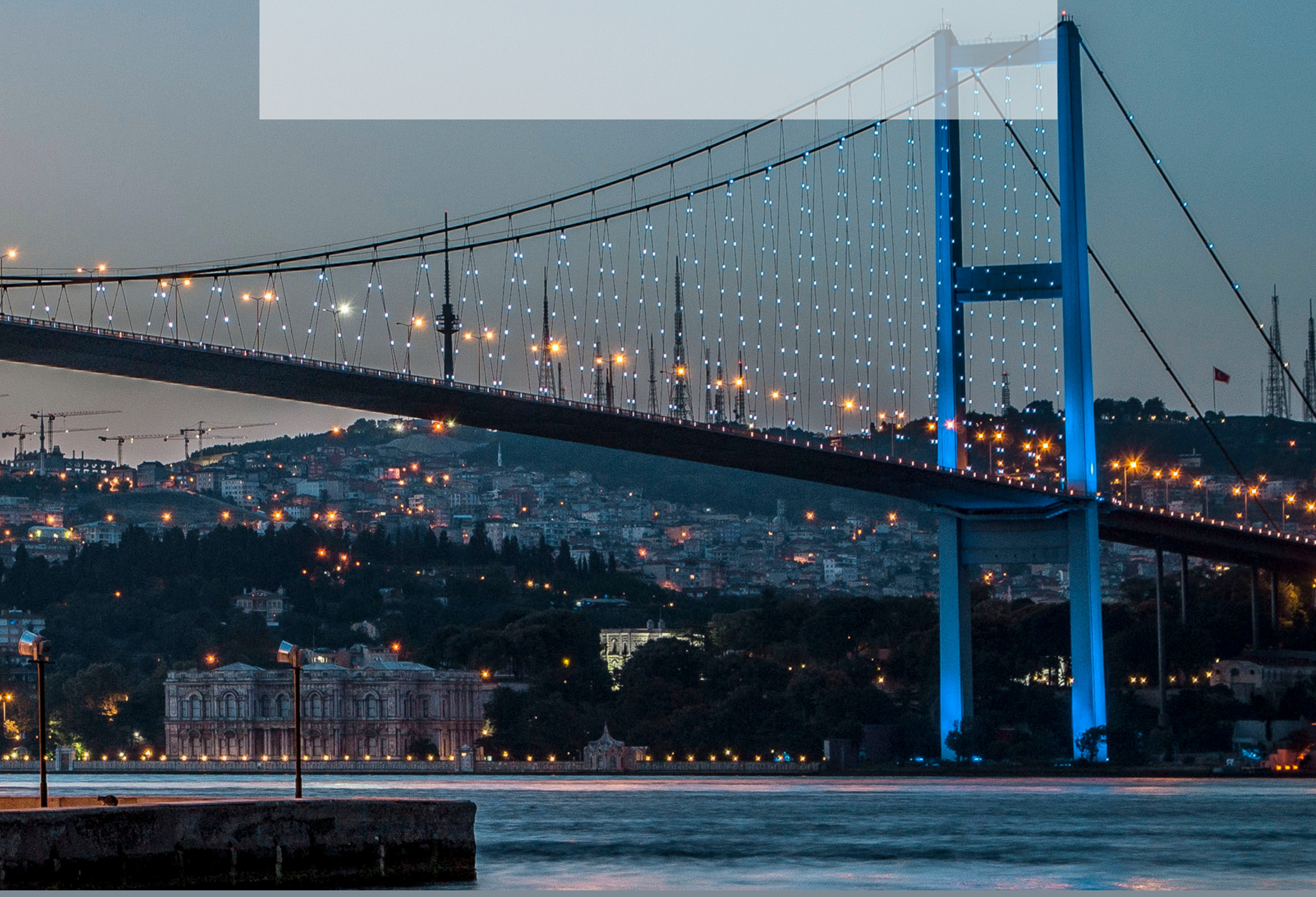
4TH INTERNATIONAL ISTANBUL SCIENTIFIC RESEARCH CONGRESS PROCEEDINGS BOOK



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NON-STANDARD FORM PRODUCTION METHODS IN LATEST ARCHITECTURE

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ABSTRACT

As a result of the development in information technologies, the reflections of the alternating environment that have been experienced in many disciplines such as genetics, mathematics and physics have also shown themselves in the field of architecture. Computer-aided design, production techniques, and computational design approaches in architectural design, model production processes and model products (models), technological developments, and modeling capabilities offered by digital media have changed design methods and the computer has started to play an important role in the design process. With the usage of computer technology and computational design techniques for architectural design purposes, new architectural approaches such as isomorphic architecture have emerged. In the isomorphic method in which the form breaks away from traditional architecture; non-euclidean, curvilinear, and organic forms have been able to design and apply with the possibilities of computational design by moving away from the rationality of Euclidean geometry. In isomorphic design, the classical architectural understandings such as right angles, principal geometric forms, proportion, style, type have been replaced by concepts such as the algorithm, parametric design, performance, complex geometry, the blob that are included in computer systematics, and fluent, dynamic, interactive, interface which can be carried through digital technology. Thus, the architecture has been introduced with form alternatives that are extraordinary, flexible, dynamic, challenging the boundaries, consisting of curvilinear compositions and complex geometries.

The aim of this study is to discuss, the place of isomorphic parametric design in past, present, and future architecture and its sustainability and applicability by examining Isomorphic Design, one of the computational design methods, through conceptual analysis and examples. For this purpose, first, literature research was conducted and the altering of the concept of form in architecture with computational design, and the concept of isomorphic architecture with its examples were discussed. In the conclusion part, the future and sustainability of the isomorphic approach were evaluated.

Keywords: Computational Design, Form, Isomorphic Architecture, Nurbs Surfaces, Blob

1. INTRODUCTION

Some techniques have begun to be developed with the introduction of the computer in form production, and in this context, form production processes have changed. Forms which have complexity that cannot be imagined with traditional design understanding, can be easily designed in digital environment using these techniques, and even can be produced at low costs thanks to file-to-factory production technologies.

The mental processes in the stage of presenting the problem in the traditional method have become the design parameters that will be defined in the program to be used. These parameters enable the system to react simultaneously to the changes made in the feedbacks during the design process, as each step is defined in the digital environment. It is necessary to determine the parameters according to the target. When the parameters and numerical models are created, more than one final product can be obtained in several variations.

Designing in the digital environment requires producing by using other methods than the usual ones. Today, the design is formed as a result of new generative systems such as isomorphic surfaces, dynamic systems, genetic algorithm, parametric supported by the digital environment, as well as physical data analysis such as the state, connections and approach of the place. Architecture has been introduced to different form alternatives consisting of curvilinear compositions that have complex geometries with the contribution of this process. Especially in the 1990s, the concept of digital design led by architect and theorist Greg Lynn had an infrastructure based on Deleuze's "fold" philosophy. The relationship between philosophy, technology and architecture began to be established (Mendilcioğlu, 2017). In this study, Isomorphic Parametric Design will be examined with conceptual analysis and examples.

2. CHANGE OF THE ARCHITECTURAL FORM WITH COMPUTATİONAL DESIGN AND TRANSFORMATION PROCESS

2.1. The Concept of Architectural Form and Its Changing

After the ancient times when simple geometric forms were used, the use of architectural elements such as arches, domes, and vaults with more curvilinear surfaces became widespread. These usages varied depending on the styles, trends, approaches and culture of the period in which the forms were used (Çakır, 2006).

Although the form seemed to be moving away from these patterns, the ninety degree angular and non-curvilinear structures in the early examples of modern architecture actually pointed out that there was still a normativity regarding the form in the 19th century (Çakır, 2006). The organic and curvilinear forms inspired by nature showed themselves from the dynamic forms of Baroque architecture to the organic architecture of the 20th century and today’s buildings that bear traces of them. These forms were left behind by traditional design, presentation methods and production techniques because they were difficult to comprehend and apply. Increasingly liberated architects have continued to search for form in order to discover the different one by moving away from these patterns that are created by architectural styles.

The 1960s were a period of interesting developments in terms of architectural form. Especially Frei Otto's efforts to develop lightweight structures got very successful results. Otto (1987), who made studies on soap bubbles, microscopic plant and animal behavior, produced many "imaginative" projects using pneumatic principles with his findings (Figure 1). In this respect, the 1970s were a period in which air and plastic materials were frequently used together (Kütükçüoğlu, 2001). It has had great contributions in the creation of today's structures.

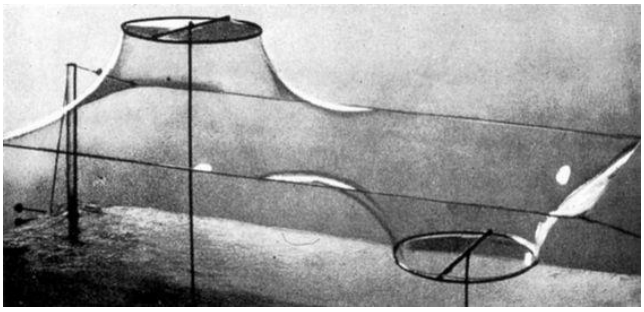


Figure 1. Frei Otto Experimenting with Soap Bubbles

Blobby forms, which can be noticed with a general perspective on the recent projects, are not just forms of digital time. In the 1960s and 1970s there was a formal approach similar to today; It was a period in which complex and amorphous forms became widespread around the world but were consumed,

forgotten or ignored at the same speed. One of the reasons of this rapid consumption and forgetting were that the technological level of this period could not realize the complex architectural forms or production processes that were considered; but some industrial objects were produced with plastic materials. However, today's technological change and development have reached a level that can produce and realize the architectural forms ignored in the 1960s (Çakır, 2006).

If bubble forms were only understood formally or used by utopian architects as in the 1960s, they would not have a huge impact on the future of architecture (Kolarevic, 2003). What architects and designers need to understand and internalize are not the bubble forms themselves, but the production techniques, technologies and digital design possibilities that allow these forms to be achieved.

Forms that remained within the boundaries of Euclidean geometry in the period when technology was undeveloped, caused that admiration for more flexible, organic and amorphous forms, in a sense for nature, became evident instantly. With being making the definition of Non-Euclidean geometries, architects and designers have gained a wide field of study in geometric terms. Curvilinear, organic forms were known and used before the usage of non-Euclidean geometries (especially in the decoration, painting, sculpture), but their reflection on architectural products has been mostly with the development of technology (Çakır, 2006).

2.2 The Concept of Isomorphic

Isomorphic means the same or similar in structure or shape. Isomorphic structures are not necessarily identical to each other in terms of appearance (Figure 2). Isomorphic design is an expression of platonic solids and Cartesian space based on isomorphic multiple surfaces.

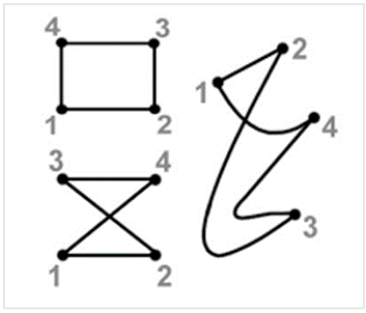


Figure 2. Isomorphic Shapes

The water drop shape (blob form), which can be called amorphous objects, is formed by mutual bending and folding with the internal force and gravity of parametric objects. New drops can be added, new relationships can be established and different possibilities can be created (Kolarevic, 2000). The terms blob 'or' metaball 'refer to intertwined spherical forms (Figure 3). Isomorphic design also covers the issues of how these objects penetrate each other in a fluid way and produce new variations by changing their shape (Kartoğlu, 2016).

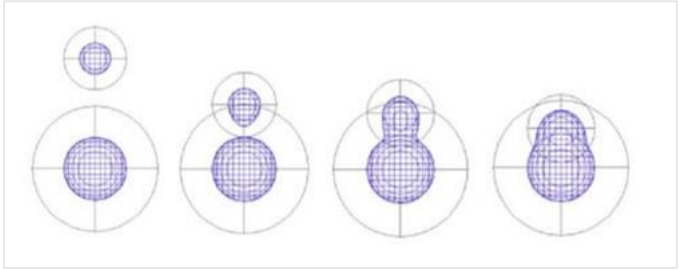


Figure 3. Formation of Isomorphic Surfaces Diagram (Kolarevic, 2000)

Isomorphic Design acts with the concept of addition and subtraction of "metaballs" made by taking Newtonian mechanics into account. Instead of bringing the two spheres together, a dome-shaped connection and a flowing, shape-shifting surface are created (Altunbaş, 2009).

Isomorphic multiple surfaces such as the blob are called the amorphous shape in which the mass of a parametric object is taken by the interacting gravitation. This exercise has the effect of adding (positive) or decreasing (negative) zones (Figure 4). The surface boundaries of the whole are affected and moved according to location and density (Yiğit, 2011).

Motion in isomorphic design is defined as the dynamics of forces that transform the form (Yiğit, 2011). This approach, also called Blob (Droplet-Bubble) Architecture, is a dynamic system where new variations can always be formed from the combination of organic forms that can stretch instead of orthogonal and rigid models (Kartoğlu, 2016).

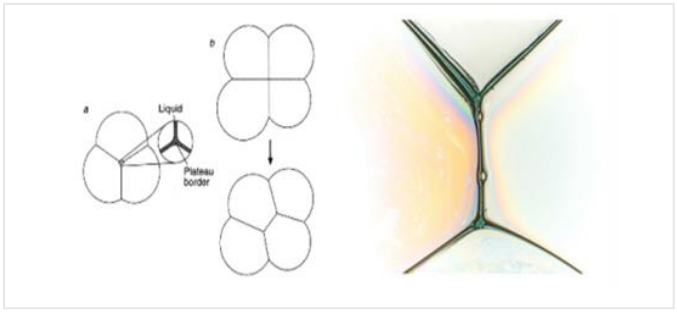


Figure 4. Formation of Isomorphic Surfaces

Isomorphic surfaces are obtained by rounding the joints homogeneously; addition and subtraction at least two spheres of different sizes (Figure 5) (Altunbaş, 2009). Motion in isomorphic design is defined as the dynamics of forces that transform the form (Yiğit, 2011).

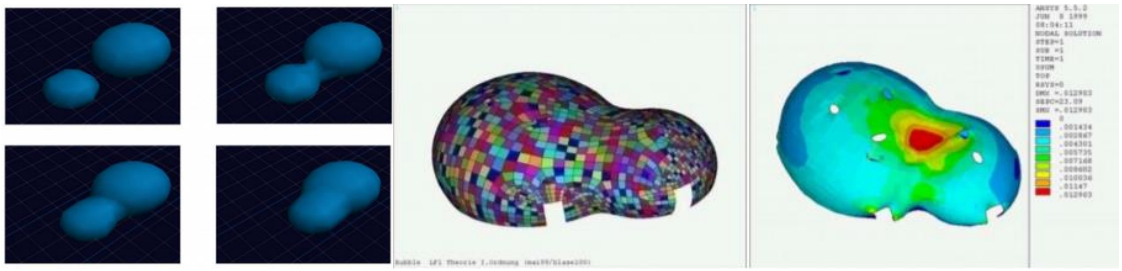


Figure 5. Combination of blob (droplet) surfaces (Yiğit, 2011)

Isomorphic design covers objects that penetrate each other in a fluid way, change their shape and produce new variations. In the 1990s, with the adoption of computer-aided design (CAD), structures that adopt unusual geometric shapes were seen to be practical. Architect Greg Lynn used the term 'Blob Stream' based on the software feature that creates binary large objects.

3. ISOMORPHIC DESIGN EXAMPLES

A wide range of research has been done to reveal examples of Isomorphic Design. It has been determined that more than one parametric design method is used in projects designed with parametric design

methods. Projects used isomorphic Design methods mostly among these projects were chosen (Table 1).

Table 1. Isomorphic Design Examples

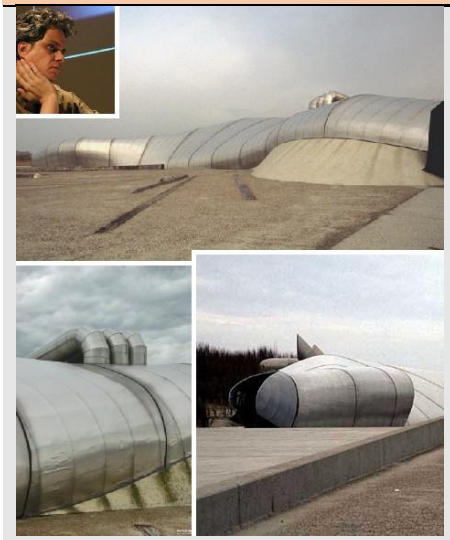
<table>
<tr><td> 
Figure 6. Guggenheim Museum</td><td>According to Bill Moggridge who is president of the IDEO, this approach of Frank O. Ghery, who has an interest in organic forms and natural figures, almost "adds nature to their structures", is more than a post-modernist attitude. In other words, it is the starting point of the 'blob architecture' movement. " The Guggenheim Museum in Bilbao, which radically breaks down the traditional museum building habits of modernism that consists a 'white rectangular prism', becomes a 'blob' architectural icon (Figure 6).</td></tr>
<tr><td colspan="2">1. Guggenheim Museum, Bilbao</td></tr>
<tr><td> 
Figure 7. Views of Water Pavilion</td><td>The Water Pavilion that built in the mid-1990s for the Delta Expo on the Dutch island of Neeltje Jans was designed using fully computer-aided tools and software. It shows the remarkable features of Blob (droplet) architecture (Figure 7).</td></tr>
<tr><td colspan="2">2. Water Pavilion, Neeltje Jans, Netherlands</td></tr>
</table>

Figure 8. Views of Selfridges Shopping Center

Studies of bring urban architecture to life with Future Systems (Jan Kaplicky and Amanda Levete) started in 2003. Selfridges Building in Birmingham, England, has an organic form covered by a shell of 15,000 aluminum discs. This innovative cover that makes the building dynamic; also highlights the facade of the building. The building reflects a fluid architectural concept (Figure 8).

3. Selfridges Shopping Center, Birmingham, England

Figure 14. Kunsthaus Graz Art Museum

The Kunsthaus Graz Art Museum that was built as part of the 2003 European Capital of Culture celebrations and designed by Peter Cook and Colin Fournier has a biochemical facade called The BIX Facade. The building is one of the isomorphic design examples with its fluid form (Figure 14).

4. Kunsthaus Graz Art Museum, Graz, Austria

Figure 11. Views of Allianz Arena

The facade of the stadium consists of 2,874 panels made of air-blown ETFE foil. It can be shown as an example of isomorphic design with this material used in the facade. The Allianz Arena Stadium in Munich, that was opened in 2006 and designed by Herzog & de Meuron, stands out as a remarkable example of architectural lighting with its extremely large-scale and lighting-oriented facade. The stadium is also the first stadium in the world that can change the color of its whole façade.

The facade of the Allianz Arena is made of a special foil material called Etfe, which is 0.2 millimeters. It is with 2.874 metal diamond plates. These panels, which emit red, blue and white light, are mounted on the front with fresh air pressure at a pressure of 0.038 HPA. although the white effect panels appear very close to each other, they actually have small dots (Figure 11.).

5. Allianz Arena, Munich, Germany

Figure 16. Eden Project Geodesic Dome

Eden Project is a large-scale ecological complex built in England. The project designed by TIM SMIT is one of the most popular tourist destinations in the UK. The complex that is an example of "blob (droplet)" architecture with its organic form consists of geodesic domes that resemble a natural biological ecosystem and contain plant species from all over the world (Figure 16.).

6. Eden Project Geodesic Dome, Cornwall, UK

Figure 12. Views of Sage Gateshead

The building that designed by Foster and opened in 2004 actually resembles a "caterpillar", as Norman Foster said. The structure has a shiny facade made of curved glass and stainless steel. The shiny surfaces offer many visual effects according to the different perspective of the viewer. The series of interconnected glass domes of building are planned for optimum acoustics performance. The structure that are formed by the combination of different isomorphic surfaces or blobs (droplets) is a good example of isomorphic design (Figure 12.).

7. Sage Gateshead, Newcastle, UK

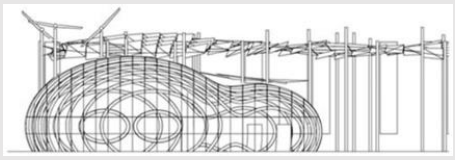
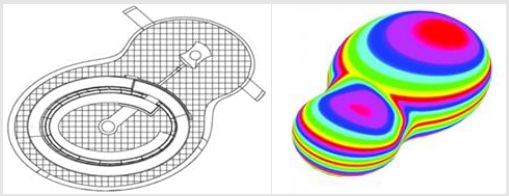
Figure 13. Views of Philological Library

The building designed by Foster that has a double-layered dome on a concrete structural core, is among the isomorphic design examples with its domed system. Also, the building that has translucent panels that provide natural lighting and ventilation on the domed roof is one of the symbols of the blob (droplet) architecture (Figure 13.).

8. Philological Library, Berlin, Germany

Figure 15. Views of Bejjing National Aquatics Center (Water Cube)

The steel space-truss structure named Water Cube designed by PTW architecture for the 2008 Bejing Olympics consists of a massive rectangular form crystallized by manipulating the geometry of water squash. The concept of the building is inspired by the structure of water molecules (Figure 15.).

9.Bejjing National Aquatics Center (Water Cube) Beijing	
  **Figure 9.** Views of BMW 'Bubble'   **Figure 10.** Drawings of BMW 'Bubble'	The BMW pavilion showed itself as a different way in architecture at the 1999 International Automotive Exhibition in Frankfurt. The starting point of the design is "clean energy". BMW that also uses this slogan for automobile designs, works on renewable energies such as hydrogen engines (Jeska, 2008). Project designed by Bernhard Franken is a good example of isomorphic design (Altunbaş, 2009) (Figure 9.). Due to the effect of bubble surface tension, the drop tries to take a round shape. However, its viscosity, hardness, atmospheric friction, and other external forces prevent it and droplet deformed into the sphere. Before sustainable development had become fashionable, Franken designed the first BMW exhibition pavilion. The drop shape symbolizes the use of pure energy from the reaction of water and air. A computer program simulating a drop has been used to create this shape (Figure 10.). This bubble is one of the world's first structures made using digital technology from appearance to construction.
10. BMW 'Bubble', Frankfurt, Germany	

4. CONCLUSION AND EVALUATION

As a result of the development in information technologies, the reflections of the environment of change have experienced in many disciplines such as genetics, mathematics and physics have also shown themselves in the field of architecture. In the first studies, designs evolved in the imagination and could not be realized. However, as a result of the experimental studies carried out over time, isomorphic design systems started to find application areas. Thanks to parametric design techniques, curvilinear and amorphous forms that have complex geometries have become able to design and apply.

In isomorphic design, the classical architectural understanding such as right angles, principal geometric forms, proportion, style, type have been replaced by concepts which are included in the computer systematics such as the algorithm, parametric design, performance, complex geometry, blob (droplet), and digital technology. In the architectural projects mentioned in this study; form that pushes the boundaries is extraordinary, flexible, dynamic and free. The freedom which manifests itself in the form, has forced the material and building system technology to develop, and has enabled the designers to produce solutions that improve their horizons.

Designers have tried to produce composite products with different combinations, to test the material performances through various stages in order to produce the desired form. They have started to work scientifically in order to reveal the formal reflection closest to the concept of design. These factors have revealed the necessity for designer’s adapting to today's digital design environment.

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