Computational design technologies for interior designers: a case study

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Abstract. Traditionally interior design is based on the inspiration generated by the designer who acts as an artist and engineer at the same time. Today, a number of digitally developed forms can be used with an aim to offer unusual geometries. Computational design technologies can be used in order to fully automate the generation of a design based on a series of parameters that can be altered within specific limits. In such a way, families of forms and proposals are made available and more opportunities for products dealing with interior design can be produced. These forms require the use of modern 3D printing technologies for their construction due to their geometrical complexity and their digital development. In the present paper, computational design will be presented together with a case study in the area of interior design.

1. Introduction
Computational design is a supportive methodology for letting designers further explore the design space in order to create innovative geometrical forms. It allows the creation of a geometry based on a number of parameters that can be altered within specific ranges. As a result, families of initial forms can be easily produced, thus pushing the design boundaries to new limits. Those limitations can be controlled by the way that the initial code is built and all the constrains set among the geometrical entities [1].

The commonly used CAD systems in product design, deal in details with the output of the design stage rather than at a conceptual level. Computational design deals with the initial form design and offers potential solutions to a significantly greater extent. The concept that needs to be expressed with an unusual geometry can be implemented and then further explore the concepts by changing the parameters and constrains used [2].

2. Literature survey
Gunduz et al. presented the implementation of computation design and design geometry courses within students and how a number of issues like cyclic process, feedback between geometric relations, material performance and joinery details were handled with an aim to achieve novel results [3]. Soleimani presented how the design process can be affected by progress in technology and computation. Computational methods were introduced to architecture schools and students were exposed in computational thinking and the fundamentals of generative analytical technologies. The key issues presented were the exploration of the computation capabilities potentials and the role that such a collection of tools and methodologies can affect the way of thinking about design [4]. These
efforts provide a solid basis that computational design and its effects in industry have already been introduced systematically in education. According to Ovesen, students with a preference in mathematical thinking have gained a better understanding of form [5]. Menges dealt with how computational design enables the biomimetic design processes in architectural applications. Morphological exploration and form-finding get increasingly enriched by environmental performance feedback [6]. At the same time, he proves the need for a different approach in engineering disciplines. The paper deals with the difference between computer aided design (CAD) and computational design in architecture, the possibility of transferring principles from nature to computational design and issues such feature-based, constraint-based etc. [7]. The present paper offers a holistic approach for the interior designers who are willing to follow an alternative path when they face a more challenging inspiration environment. Further to the proposed methodology, a case study is presented with an aim to offer a paradigm of successful implementation of computational design.

3. Proposed methodology
Interior design faces a number of challenges from the inspiration and implementation point of view. Designers sometime feel that there is a lack of appropriate CAD tools for expressing their ideas or they limit their inspiration due to limitations for 3D representation of their idea. Figure 1 depicts the proposed methodology for interior designers to follow in the area of decoration, lighting, furniture etc. Following that approach, all the product development steps are implemented with CAD based tools i.e. the conceptual design sketches, the initial inspiration 3D forms and the finalized virtual products based on advanced render techniques.

With an aim to overcome the problems of 3D modeling unusual geometries, the use of computational design introduces extra freedom from the designer’s point of view. Advanced tools offer the possibility to model every geometry the designer might have in mind. At the same time, through the use of 3D printing technologies, those design can be produced in a limited amount of time without the manufacturing restrictions of other traditional processes i.e. molding, casting.

4. Case study
The central idea was to model a room/office divider focused on simple geometries, such as boxes, based on the principles of computational design. The process starts with a number of nodes in space, that can be connected and implement an unusual but well-designed geometry. The basic aim is to create prototypes that will have the same external dimensions and with their appropriate assembly more alternative designs will be implemented. So their combination can offer the freedom to finally have an infinite amount of design combinations of the output presented. The components of the proposed structure will be kept constant with appropriate metallic connectors. The connectors will be placed towards all directions so positioning the component will be safe for use. Figure 2 provides an

![Figure 1. A holistic approach in interior product design.](image-url)
overview of the conceptual tools used in order to get the inspiration for the proposed design i.e. mid map, mood board, sketches.

| Case Study          |
|---------------------|
| Room and office divider |

| Conceptual Design Tools         |
|---------------------------------|
| Mind map                        |
| Mood board                      |
| Unusual geometries              |
| 3D printing                     |
| Divider                         |
| Nature forms                    |
| Root morphology                 |
| CAD-based sketch (Basic idea)   |
| CAD-based divider combinations  |

**Figure 2.** Conceptual design tools implementation.

| Case Study          |
|---------------------|
| Room and office divider |

| Conceptual Design Tools         |
|---------------------------------|
| Grasshopper™ parameters         |
| Rhino™ Model                   |
| Divider combinations            |

**Figure 3.** Applying computational design principles.
Grasshopper™ was used for creating the appropriate code. A series of geometrical parameters and constrains were introduced and the user was able to change them within a specific range of values. The Rhinoceros™ model created in each case, an angle was incorporated that permits the positioning of the divider in different directions, thus allowing the shape of the divider to change and provide a significant number of combinations (figure 3). Those configurations can create a straight line, a series of arches, U turns etc. In addition, some components can be subtracted in order to have the total geometry of the divider with a variety of alternative designs offered.

Due to the complicate geometry of the proposed box-like part, 3D printing should be used for its production. This offers additional advantages because more colors can be selected for the material used and at the same time specially manufactured wood like materials (powder of wood together with PLA) can be used. The result is to be able to offer a great deal of shapes, colors and textures when dividing a room or an office (figure 4).

| Case Study |
|---|
| Room and office divider |

| Product Design Renders |
|---|
| Final alternative pieces of divider model |

| Divider combination | Interior usage of divider |
|---|---|

![Figure 4. Alternative geometries of the divider.](image)

### 5. Alternative forms and product family

Further to the different designs of the divider component, computational design offers additional advantages by exploring the use of the same principles in other components used in interior design products. The use of the same 3D printing technology with alternative materials and colours can be extended at components made for an office desk (figure 5). In the same way, the unusual forms and geometries produced can offer distinct advantage from the appearance point of view, when presenting a similar form with the previously described space divider units.

It offers a unique opportunity to link the traditional minimal design of an office desk with high tech based computational design of the desk’s support with components that look more futuristic. In this way, one side of the desk looks similar with what the customer expects to see on a desk, while at the other side forms and geometries generated from computational design offer the sense of similarity with the divider previously described. The increase in productivity is significant because with similar
computational code an extensive number of components can be produced in a limited time and manufactured following widely accepted 3D printing manufacturing processes.

| Case Study |
|------------|
| Desk supporter leg |

| Product Design Alternatives |
|----------------------------|
| From basic divider form to desk supporter leg |

Figure 5. Family of products following the computational design approach.

6. Conclusion
A holistic approach in designing products was presented with an aim to use computational design together with a number of conceptual design tools and methodologies. When the proposed framework is used the designer can offer unique geometries for the customer, 3D printing capabilities for their manufacturing and a family of products that relate to each other and perform an eye catching feeling to the potential customer. The contribution of this paper aims to update the interior design point of view on digital tools usage (i.e. computational design). Although all these technologies are still under development and the design engineers try to find application for these tools, it seems that there is a shape shifting trend towards futuristic product design components to accompany ordinary traditionally presented products.

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