# Computational based product design: a 2D-pattern related case study

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**Abstract**
The most common way that product design related industries use CAD systems is by successfully implementing the use of solid models with mainly prismatic geometries or expand to surface models with additional effort. Nowadays, computational design has offered a great deal of advantages in creating non-conventional geometries and harder to implement 3D models via programming interfaces. Textual and visual CAD programming tools have been developed and offer a great deal of assistance to the designers and developers. Automating the geometry creation is associated with the easy creation of families of products and not just one product itself. The present paper aims in presenting a case study in the area of interior design using 2D mathematical based geometrical patterns via visual programming CAD techniques. The uses of the methodological tools involved are coupled with the computational design in order to give a number of impressive alternative designs. Following the proposed framework an increased size of the design space is examined and the outcome offers additional advantages.

**Keywords:** computational design, visual programming, interior design, 2D patterns

## 1. Introduction

Over the years, computer aided design (CAD) based design has been used in a number of applications and solutions. The use of CAD can be described from both the modeling point of view and the downstream applications created in order to enhanced designers' capabilities and productivity. Traditionally, CAD tools are used by designers that know how to operate them, when using the graphical user interface (GUI) offered by their manufacturers. They all try to make these tools more intuitive and easier to use, while at the same time, a great deal of effort and funds are spent in training courses and activities [1].
Nowadays, a new approach has been used and offered by the CAD manufacturers to the designers, with an aim to increase their efficiency. All general purposes CAD systems offer an application programming interface (API) in order to encourage designers to create in house applications using computer programming languages i.e. visual basic for application, python [2]. As a result, the role of designers becomes more challenging. There is a need to get an inside knowledge of the CAD systems, training and skills in CAD programming, while at the same time, they should insist towards increased component and product standardizing. This is extremely important because it is the way to follow, when coding design practices and families of products.

## 2. State of the art

Researchers from a variety of backgrounds find interesting outcomes when using 2D patterns as the basis for their designs. The 2D patterns are transferred to 3D and vice versa but at the end of the day they both help creating and automating the design process in a lot of engineering and artistic eras. Those designs can be used in 2D or 3D applications and can offer distinctive advantages of innovation and alternative proposal implementations. In order to achieve those excellent results, different frameworks, techniques, tools and manufacturing processes are implemented via advanced computer aided design. Designers especially those with industrial engineering background feel comfortable with the information transfer needed from 2D drawings or sketches into 3D final models. A number of industrial applications give a great deal of attention to 2D geometries as the basis to introduce 3D models to their final product.

Graziosi et al implemented an algorithm in order to take advantage of the 2D leaves patterns found in nature and deliver the 3D geometry of a lamp. The product was inspired by Physalis Alkekengi, a plant found in nature, so there was a combination of product design based on biomimetic. This procedure offered advantages from the aesthetics point of view and lead to creating and unusual geometry. Grasshopper™ was used for this process and the result was 3D printed during the prototype building phase [3].

Mori and Igarashi have implemented and interactive system for designing plush toys. In this case, the user needs to define the appropriate 2D pattern geometries with an aim to assemble a 3D model of its own toy. Although sometimes there are problems of mismatch, the application is correcting the geometries when necessary. The transfer from 2D to 3D takes place directly and the final product is a good approximation of the requested, while at the same time optimal layout and design accuracy are taken care of later on the product design cycle [4].

Igarashi and Suzuki uses a system that reads a 3D model and is able to produce the appropriate 2D patterns that when manufactured the final product is able to offer a realistic and accurate result. This approach is very useful within the fabric industry and can relate the transfer from 2D to 3D geometry needed [5].

Decaudin et al. presented a system that can start with the use of 2D sketching as an input and can take the user up to the final 3D mannequin creation with the virtual clothes on. This is a classical application that demands interaction between 2D and 3D geometrical entities and needs a great deal of attention on the technical aspects of the 2D patterns sewing. The final representation is very detailed and can imitate the 3D cloth representation in real life [6].

The current paper aims in presenting a case study in the area of interior design that is using computational design in order to produce a series of 2D pattern-based products, without redesigning the products from the beginning. Setting up the design algorithm, to start with, needs extra effort but later when a large number of alternative designs becomes available on shorter time an advantage is grasped. Of course, the whole process, involves the use of a variety of methodological tools in order to increase inspiration and guidance for the designer.

## 3. Proposed methodology

The targeted product design is the decoration of wall panels based on interior design effectiveness. Although, these activities usually are based on the individual designer inspiration in our case, a series of steps were followed [7]. Fig. 1 depicts the workflow schematics and the different steps followed.

The basic inspiration came from the use of 2D mathematical patterns, motifs and geometries mainly available in the literature [8]. Then modern computational design tools were used in order to produce a complete code that offered a large family of alternative designs, when different parameters were taken into account with several values. The designs that were passing the initial stages were further processed via advanced CAD pieces of software in order to be ready for downstream application utilization. Model advanced rendering as standalone geometries or inside a virtually built environments helped to develop further all the interior design and decoration proposals thus enhancing their prototype visualization added value, early in the product design phase.

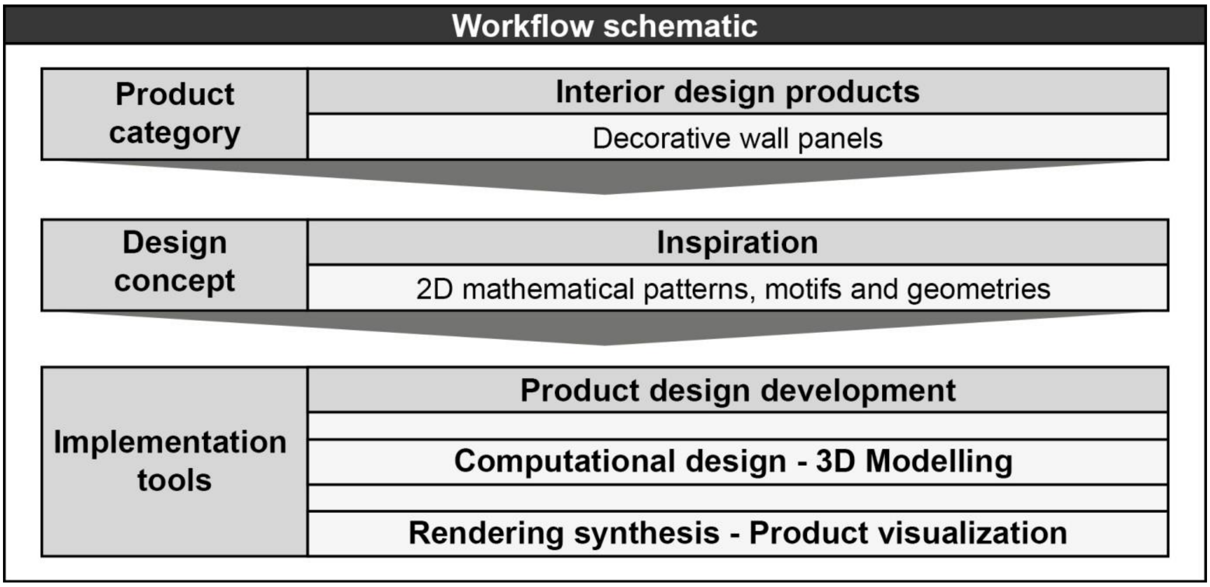


**Figure. 1.**Presentation of the workflow followed

## 3. Case study

Internal space design was always a very interesting topic and received a great deal of attention. Inspiration and implementation were both following the skills and competency of the designer so it is usually presented as a procedure that can be followed from specific designers that can incorporate both. Our approach is different and underlines the use of a variety of methodological tools for developing ideas from inspiration to design and virtual prototyping (fig. 2).

Both the mindmap and the moodboard methodologies were used as a first step to explore the possibility of getting inspired from different eras i.e. architecture, mathematics and geometry, cultural content, and the result was to focus on 2D patterns and motifs supported by mathematical equations and graphs. They all can be used for the implementation of a variety of alternative designs. Then using the advantages offered by a number of sketching alternatives, families of designs were produced. As a result, a large number of possible products were discovered. The final stage was to build a storyboard with an aim to present the ideas in a modern context than would emphasize the pluralism of the design outcome. Finally, photorealistic images were used for presentation purposes. The geometries themselves separately and within the environment that is proposed to be used are rendered using high end computer applications.

Grasshopper™ was utilized in order to incorporate the ideas and designs discovered in the previous phase and translate them into a code based on a visual programming language. Through the code generated, great deals of parameters were embedded and a lot of alternative designs were presented (fig. 3). In addition, the code offers the possibility for additional output formats in order to have access in a variety of technologies and tools i.e .stl file for 3D printing services, vector files for operating laser cutting and engraving machines.

A selection process was followed and finally four 2D alternative patterns were selected to be offered. It should be stressed that those proposals can create even more alternative designs based on the basic characteristics encoded with Grasshopper™. Fig. 4 depicts separately:

- the vector design, which is the base of each synthesis proposal
- a render image of the individual 2D base for the proposed pattern

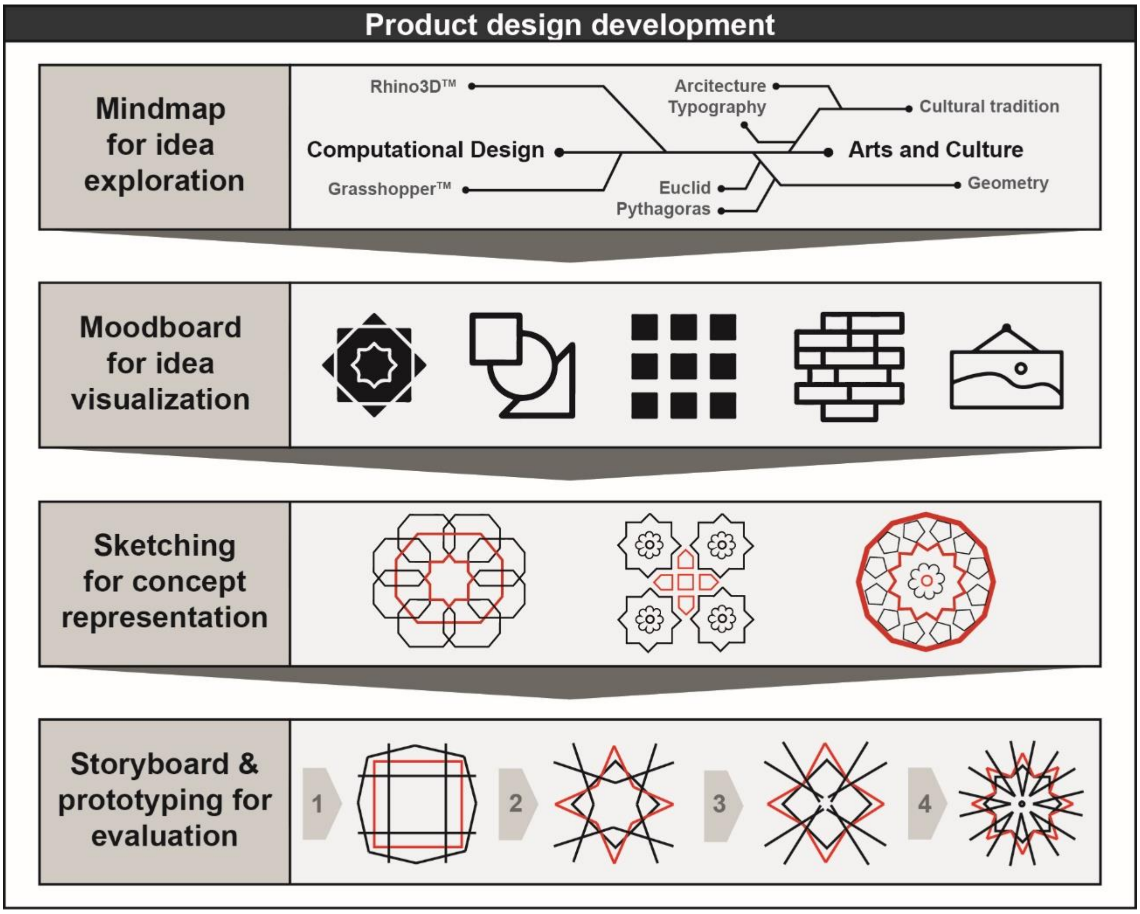


**Figure. 2.**Methodological tools used

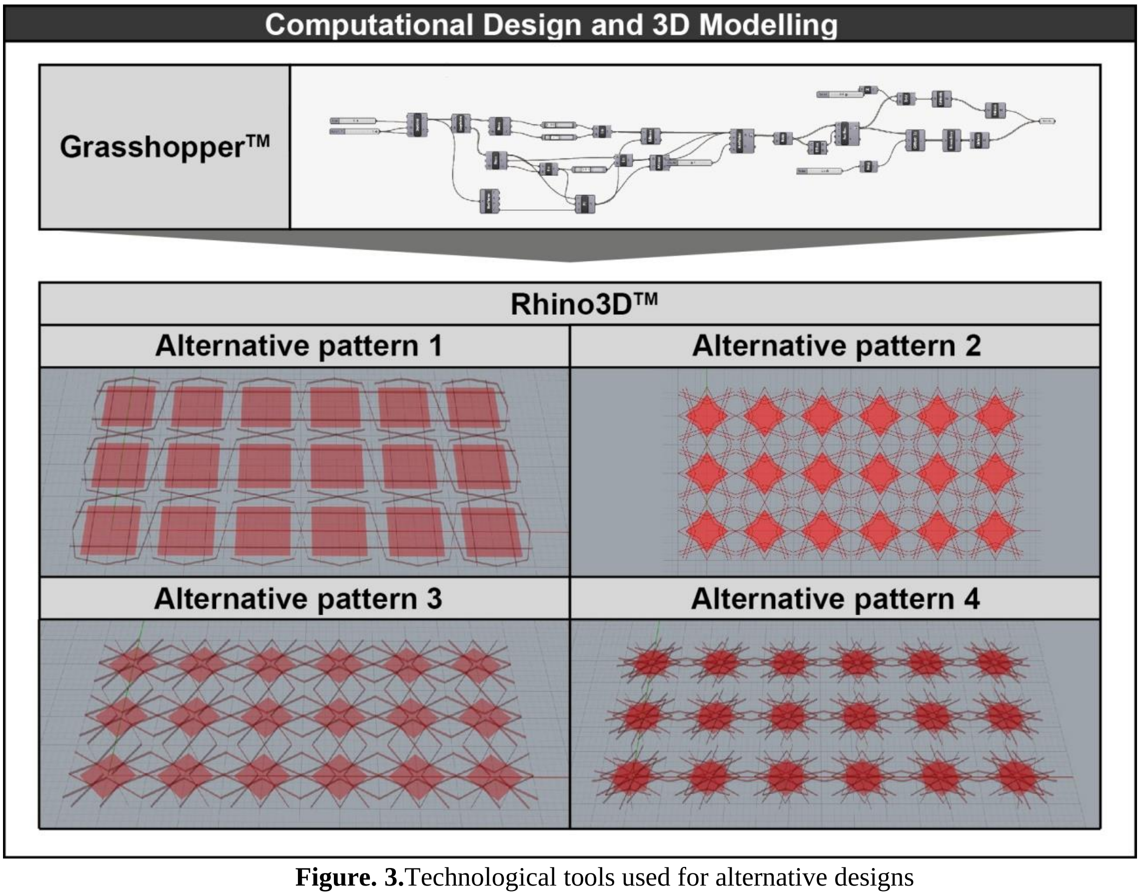


**Figure. 3.**Technological tools used for alternative designs

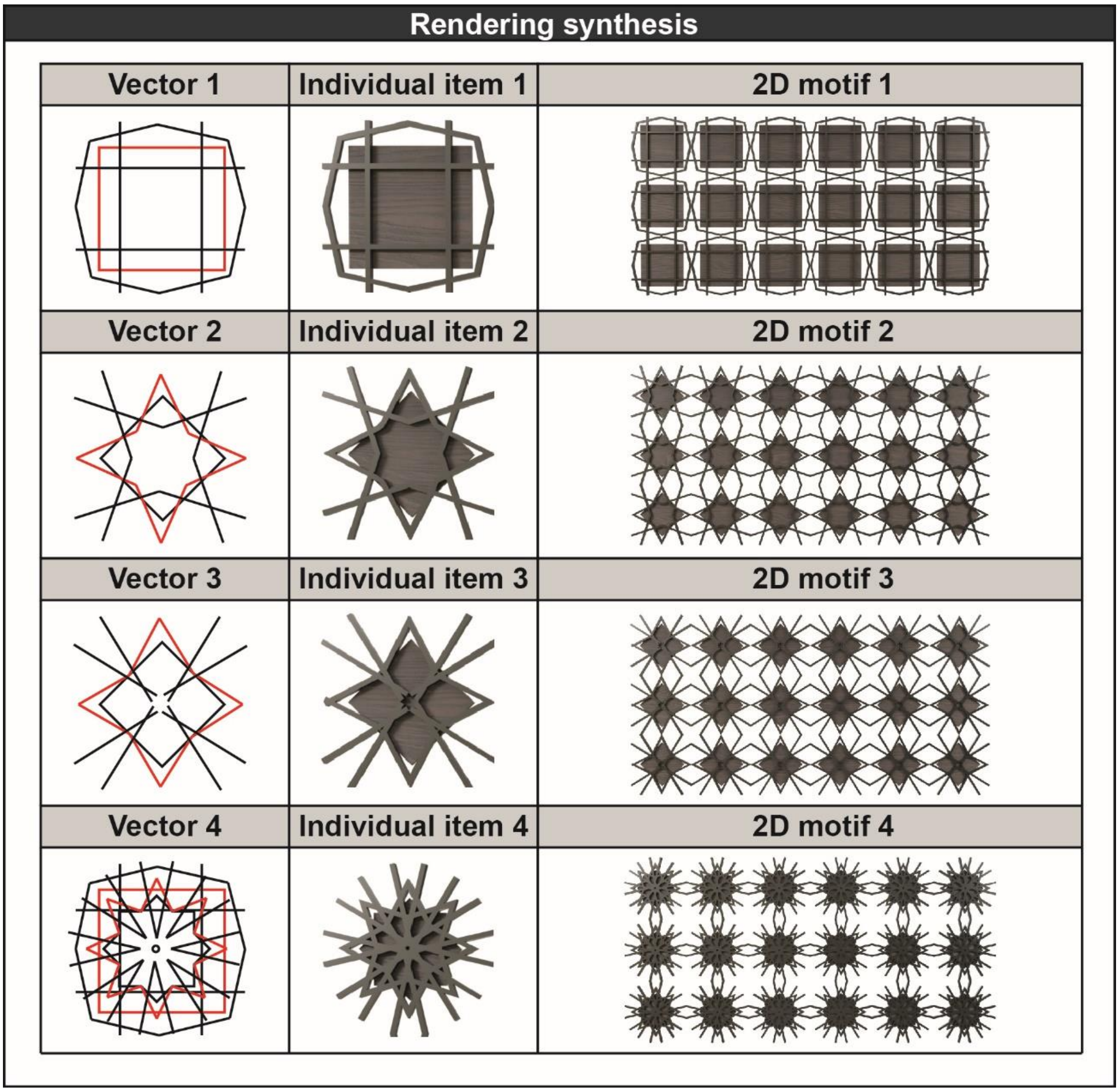


**Figure. 4.**Visual prototyping of four 2D geometrical patterns proposals

- a render image of the 2D pattern set of each individual proposal.

Someone can argue that these 2D geometrical pattern proposals are very much different, when seen all together in the same figure. It is the authors' opinion that this is correct and provides a solid basis for the advantage offered by the proposed methodology. The designer is able to expand the explored design space to a great extent and discover high potentials in ideas that are difficult to be extracted if this work framework is not used.

Fig. 5. depicts a number of photorealistic images that aims in emphasizing how the proposed designs can be incorporated. It is a way to stress the impact of the proposed 2D patterns used on the final product that relates the outcome with the interior design principles. The advantage presented is that using the code implemented, the alternative designs can be increased in numbers, while at the same time someone can see a very realistic view of the final product inside the space of use. The latest leads to increased satisfaction because the designer can offer a more complete experience to the user prior to building the final product.

## 4. Conclusions

In the current research, a framework was presented, that manages to incorporate a series of methodological tools (i.e. mindmap, moodboard, sketching, storyboard) with computational design in the area of 2D mathematical patterns, motifs and geometries (i.e. Grasshopper™, photorealistic images). There are a number of advantage following this strategy and tools. The designer is able to examine a greater area of the design space available and expand the opportunities for novel ideas and inspirations. Then a number of technologies were used with an aim to improve the product's virtual prototype presented, while at the same time more technologies can be utilized (i.e. 3D printing, laser cutting and engraving).

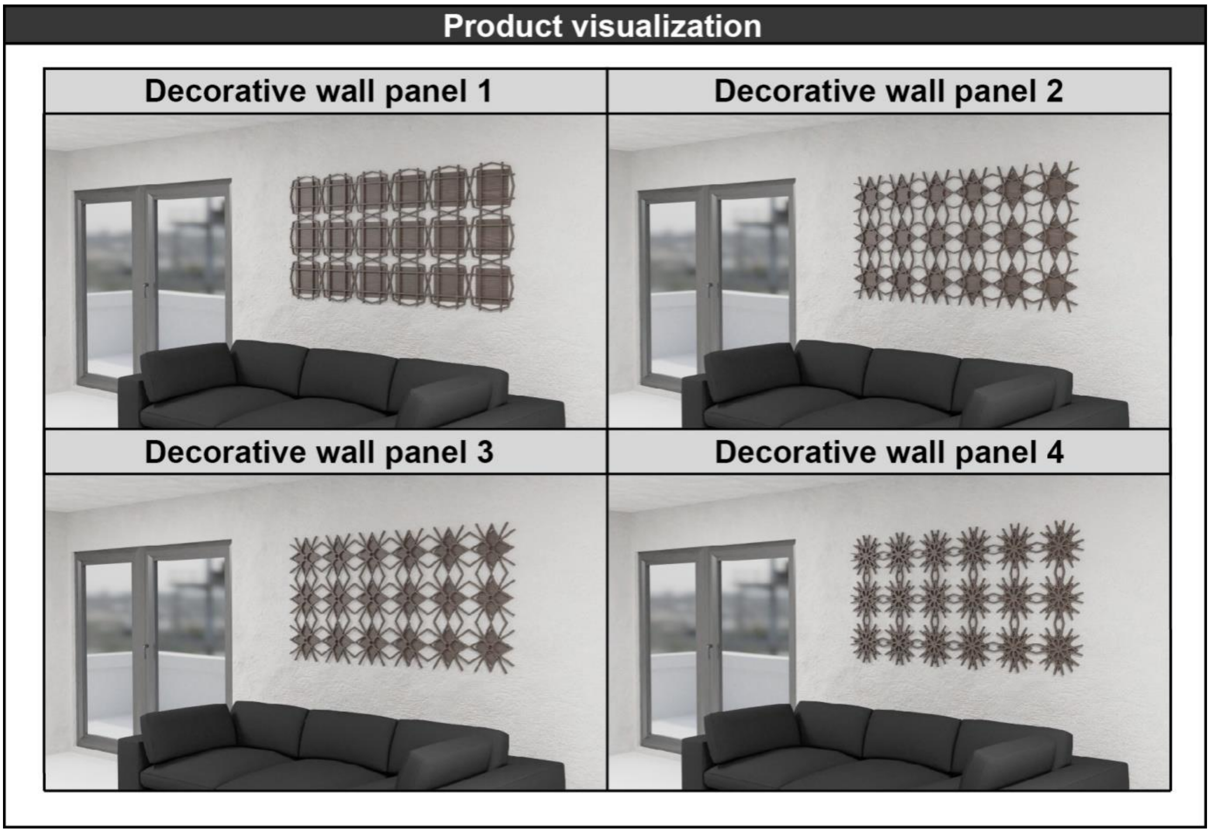


**Figure. 5.**Virtual prototyping

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