COMPUTATIONAL INTERIOR DESIGN BASED ON 2D PATTERNS

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Abstract: *Modelling with 3D CAD (Computer Aided Design) tools has reached a point that its complexity is difficult to be controlled without the use of programming tools. Both general purpose CAD systems and specialized CAD pieces of software allow their programming with textual or visual interface. The designer is offered with a variety of tools in order to automate the design process and handle its geometrical complexity. The present paper deals with the use of CAD based visual programming for product designers, who want to use unusual geometries based on 2D patterns and present their work to the final user using high-end rendering images. The proposed designs can be customized to a great extend and contribute towards their increased added value. At the same time, a family of products can be presented, when the design parameters used get alternative values*

Key words: computational design, 2D patterns, interior design, CAD programming

1. INTRODUCTION

Product design as a key procedure in the development of new consumables. It applies a number of methodologies and tools in order to satisfy the customer demands. A great deal of methodologies has been developed and some are taking the conceptual design to the limits of art (Manavis et al., 2017). Except for the application of different methodological tools, modern CAD/CAM/CAE pieces of software become more popular, and the designers are willing to expand their knowledge and expertise in incorporating them in their day-to-day design process (Kyratsis et al., 2020).
Programming skills in the product design industry are becoming mainstream and the design related university curricula incorporate this trend more and more. This can influence the quality and speed of the design process, the creativity and optimization in a variety of aspects (Hirz et al., 2017; Song & Yang, 2021).

2. LITERATURE SURVEY

Product design provides a solid basis for a variety of aspects to be researched and developed. A number of points of view can be adopted and as a result to be further developed.
Efkolidis et al. (2020) incorporated computational design tools in order to develop jewellery design alternatives. The designs use additive manufacturing technology in order to receive 3D printing detailed models. Stereolithography (SLA) is the most well-suited technology for these prototypes and the dimensional accuracy received.
Gastro Pena et al. (2021) took advantage of the artificial intelligence aspect of computational design in order to present a review paper in searching the design space. The aim was to gather researchers that employ early enough artificial intelligence methodologies and tools in order to optimize the design of architectural forms.
Cheng et al. (2021) deals with 4D printed wearable systems based on the computational design approach. The proposed biomimetic design strategies are used in order to implement 4D-printed mechanisms for motion. They deal with adaptive creations of wearable systems that can greatly impact the design process.
Kyratsis (2020) and Kyratsis et al. (2018) provided a solid basis for establishing CAD-based product design and computational product design methodologies. Alternative shape development and automated design of pneumatic cylinder systems based on the appropriate international standard, offered added value in designing with time restrictions.
Sun et al. (2022) use computational aids and 3D tools in order to design ceramic products. A number of alternative ceramic designs are developed based on the initial prototype and redesign it. 3D printing technology is extensively used to help the implementation of the proposed methodology that results in the final design of a group of innovative ceramic toys based on the properties from Changsha Kiln.

Sun et al. (2021) presented FlexTruss application that enables parametrical design based on the assembly of modularized truss-shaped objects. Those objects can be manufactured using 3D printing devices and be assembled by threading. There is a significant part of the research that aims in enhancing the design capabilities in 3D space via human-computer interaction tools, so CAD based programming is implemented for this reason.
Saric et al. (2020) uses Computer Aided Design (CAD) under the intelligent and integrated system development. The outcome is an application that designs and develops bridge crane geometries while utilizes knowledge and expertise that are incorporated within the final application.
Manavis and Kyratsis (2021) and Manavis et al. (2020) proposed the use of advanced computational design tools for product shape generation, jewellery design and wearables development. They make use of a complete methodological proposal in order to apply the computational strategy in a variety of product design areas.
Tzotzis et al. (2021) automated the generation of the necessary G-code for a number of drilling operations from different directions on a CNC machining centre. A general purposes CAD system is used via its Application Programming Interface (API) and it is utilized for implementing a user-friendly piece of software that guide the G-code generation for machining purposes. The quality of the produced codes was checked, and their high quality was proved experimentally.
Garcia-Hernandez et al. (2016) developed a CAD-based application for designing noncircular gears manufactured by wire electro-discharged machining. The increased accuracy achieved offers a great deal of advantages in the design and manufacturing process.
The present paper uses computational design tools in order to take advantage of the ability to use 2D pattern mathematical equations and transfer them into the interior design industry. As a result, innovative ideas can be transformed to customized products that can be presented to the customers very early during the design cycle and thus increasing their satisfaction.

3. PROPOSED METHODOLOGY

The proposed ideas are part of a holistic design process that involves design methodologies and tools, together with CAD based programming principles. It deals with the customization of interior design products in order to produce decorative wall panels. The geometries are inspired from 2D motifs and geometries while modelled with computational design applications. The final geometries are not only presented to the customer but stress the idea of customizing them with a great deal of variations in a fully automated way. At the same time, advanced tools for rendering the proposed designs are used together with product visualization, using high quality graphics. Figure 1 presents the proposed framework that applies the holistic methodology in the computational interior product design era based on 2D pattern geometries. First the product category is selected, and interior design is highlighted, then the inspiration from 2D motifs provide a set of variations, with an aim to establish strong customization characteristics and finally the product development incorporates computational design 3D modelling and product visualization tools.

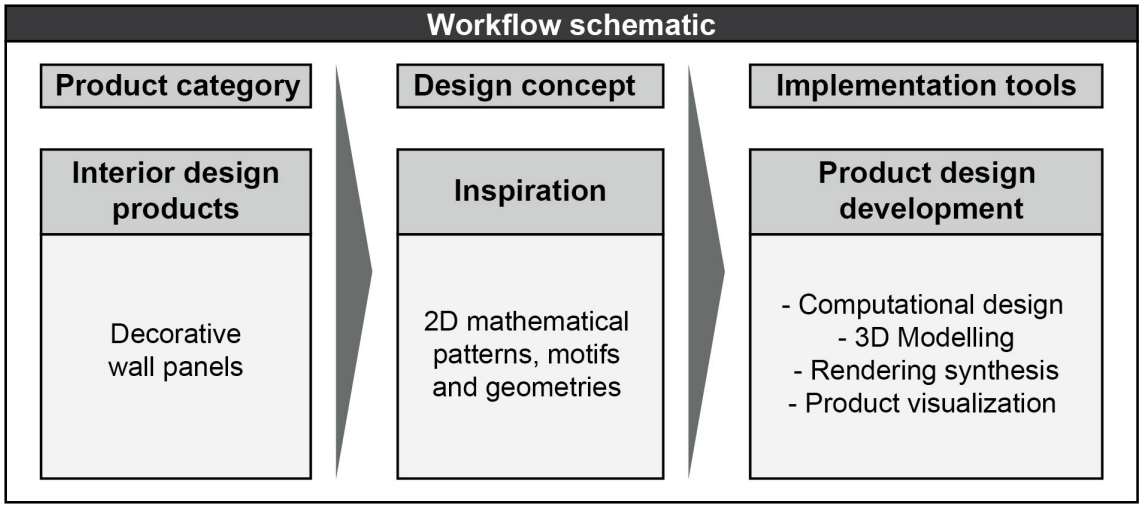

Figure 1: The holistic framework used in the computational interior design methodology

4. CASE STUDY DEVELOPED

The implementation of the proposed methodology offered a unique opportunity to develop interior design related products, decorative wall panels in this case. A number of methodological tools established the idea behind the developed case study (Figure 2). Mind-map was used in order to explore the different aspects of the design space and conclude innovative ideas. The use of computational design was at the heart of the problem while artistic impact and cultural influences led to using parametrically high end 2D & 3D tools in the design of geometrical shapes.

Mood board was used in order to explore the different patterns and establish a strong link of the design team with these patterns. It was the first step that helped the discovery of new directions towards geometrical complex geometries that played a key role later.

CAD-based sketching offered a number of impressive geometries to be modelled and presented in a way that combining different characteristics resulted in innovative patterns from the geometry point of view. Digitally delivered sketches helped the information transfer from one stage to the other without losing data in digitizing and reducing their quality.

Finally, the storyboard used created a road map that the design team could follow and produce actual unique designs to be implemented later on with advanced CAD and rendering systems. This stage was completed when new directions of the proposed designs were established. It is this stage that some designers say could be omitted, while it is the authors strongly belief that this is the stage that most of the unusual ideas find their way towards implementation. This is the basis for the presentation of the conceptual design results that later are implemented with advanced CAD systems.

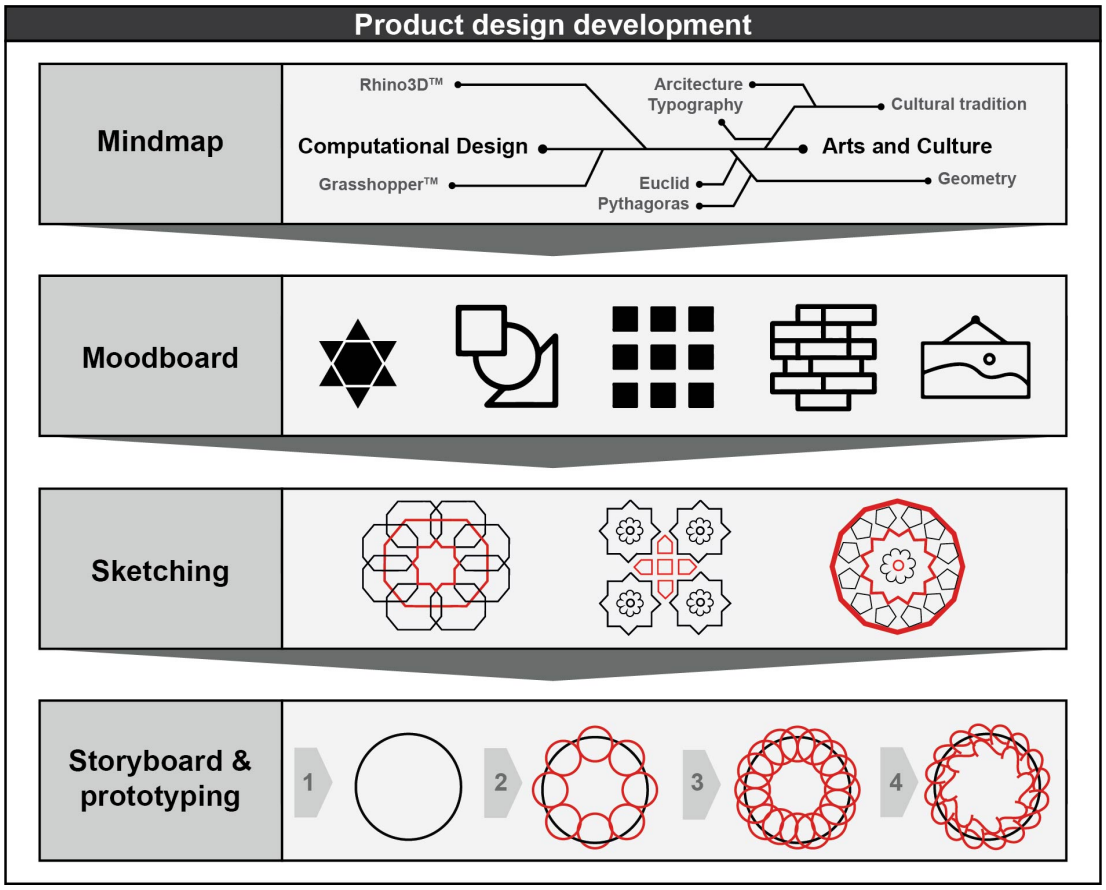

Figure 2: Customized ideas development using methodological tools

Grasshopper™ was used as the tool to automate the design process and provide a solid basis for altering design parameters and receive customized final 3D models. Those models were built on the previously generated idea, to incorporate a number of 2D patterns and alter their geometrical characteristics with an aim to offer a great deal of different designs that could satisfy every customization preferred from the customers' point of view. Grasshopper™ is part of Rhino3D™ and can be used as a visual programming

language that can be learnt relatively in a short period and at the same time, to incorporate equations, parameters and geometrical constrains under the same roof.
The designer after establishing the computational design code, written with the CAD visual language, is able to change the parameters involved and present an infinite number of variations and alternative designs. Figure 3 depicts the code built with Grasshopper™ and some alternative designs that can be presented to the customers. While changing the parameters involved the customer can make his own selection directly and feels that he actively participates in the design process with the designers.

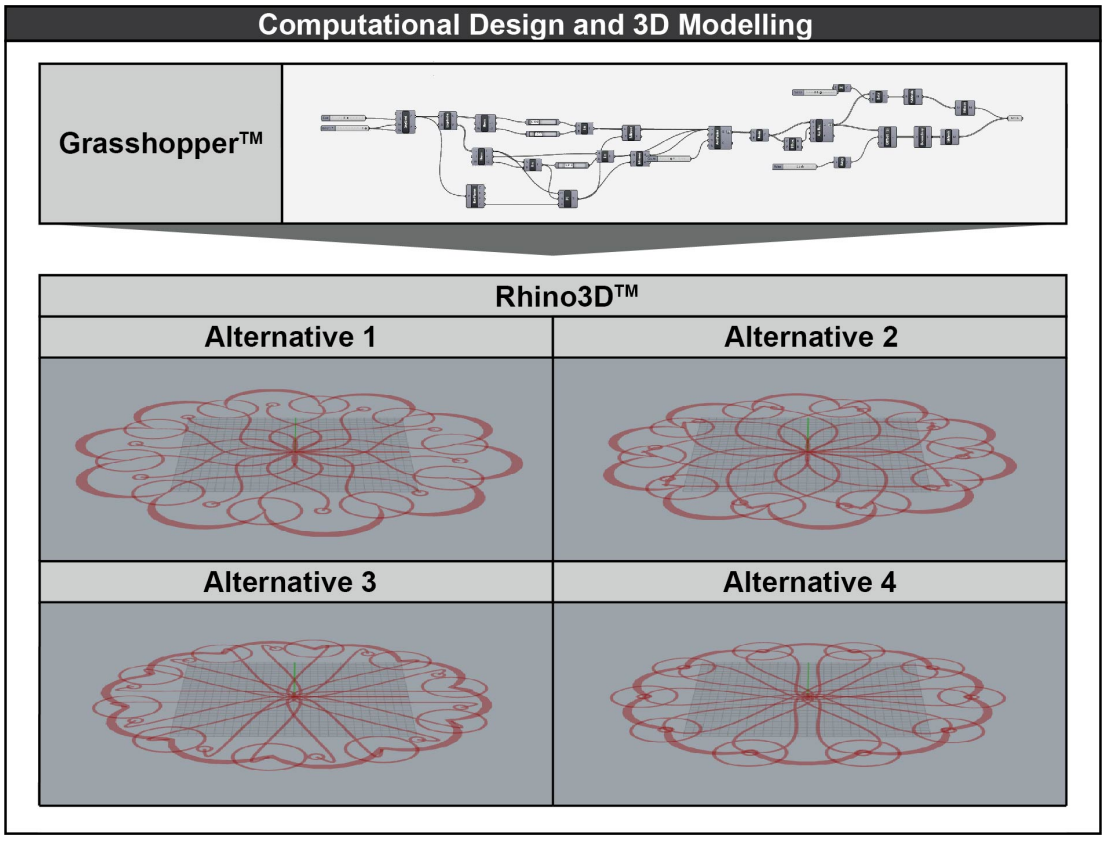

Figure 3: Implementation and alternative designs based on 2D patterns

Translating the selected design into vector-based geometry, a first set of alternative designs can be built with an aim later to strengthen those designs with the use of linear and circular motifs. Figure 4 reveals that the number of variations is extremely high, while the visual code built is able to change in real time the proposed design. These variations, that the decorative wall panels are based on, can be offered as design proposals and include the customers' wishes online.
The 2D proposals offer a useful tool for visualizing the final result but after that 3D models are created. Those 3D models together with the appropriate visual effects, led to creating a 3D render representation of the alternative motifs built within their use environment and ask from the customer to finally choose the best product that fits to its needs, the artistic and the cultural experiences (Figure 5).
At this final stage, the customer is able to actually see with the use of high-quality 3D models and graphical environments his proposal in an extremely realistic way, thus helping both the designer and the customer to agree on the final decorative wall panels design to be acquired very early in the design cycle.

5. CONCLUSIONS

The combined use of the proposed methodological framework, together with visually programming language that guide the CAD tools used is presented in the current research. The case study presented deals with high quality 3D representation of interior design products. The methodological tools are used at the beginning of the process in order to create unusual and innovative ideas, while transferring them

to the computational design tools for automating their design process. The code produced offers the possibility to explore the design space together with the customer with an aim to satisfy his demands. Finally, a computational design tool is produced and transfers the initial design ideas into high quality 3D rendered products within a 3D graphical environment and the final output is high-end rendering images.

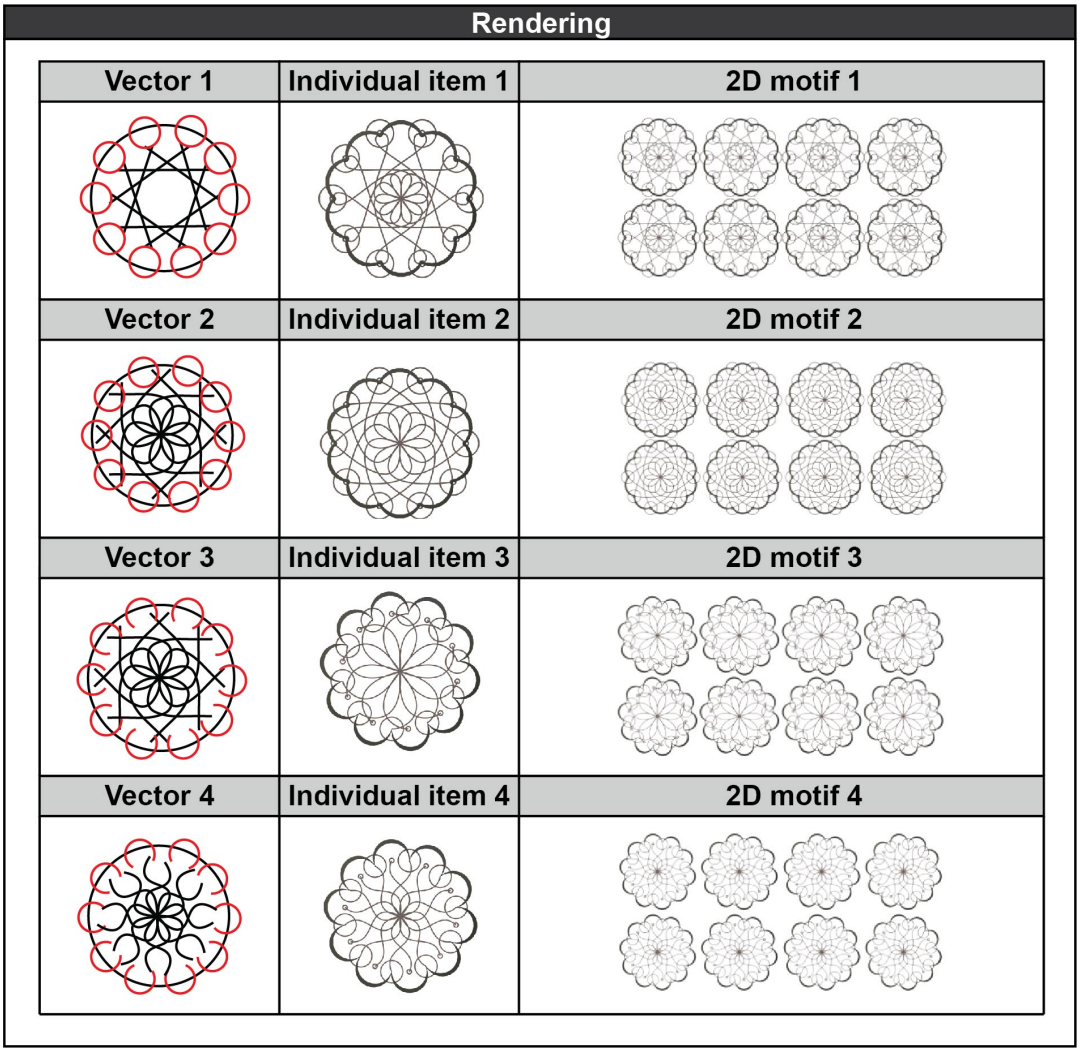

Figure 4: A series of alternative designs produced by computational design

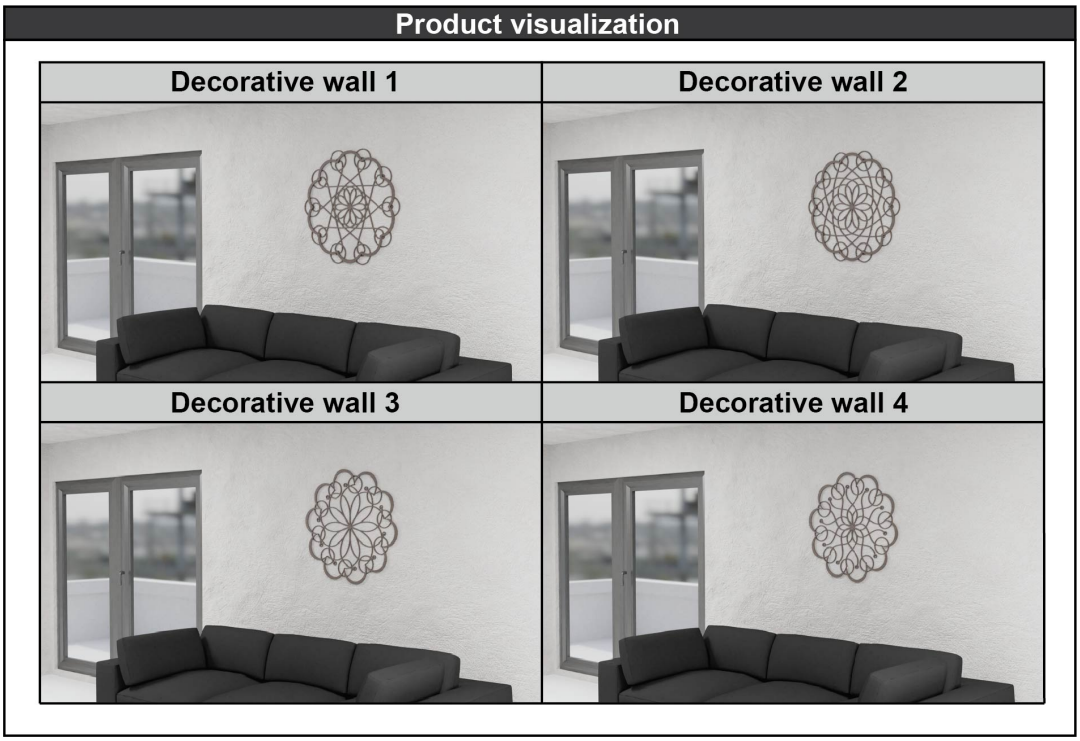

Figure 5: Rendered appearance of the proposed interior designs

The impact that the customized designs offer to the customer, when his involvements is so direct, is very high and provides the experience of co-designing the decorative wall panels and agree on their successful outcome. At the same time, it decreases drastically the ambiguity of delivering exactly what the customer has requested because the high-end environment with the wall panels offer a realistic representation of the final product inside the virtual environment.

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