CAD based design for the jewellery industry: A case study

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Abstract. Jewel design is performed for many years and the designers and manufacturers follow a variety of inspirations. Traditionally the designs are generated based on the artistic sense of the creator, while at the same time a number of manufacturing restrictions apply. Nowadays, a series of advanced Computer Aided Design, CAD based tools are available in order to generate impressive concepts. Although, it is possible for designers to interface a CAD system and implement their design digitally, some prefer to use the programming capabilities offered by the CAD software developers. This is the way forward, in order to create unusual geometries for the jewellery industry and at the same time to develop the capability for generating a complete family of geometries that can satisfy even the most demanding customer. In the current paper, the latest approach is presented together with a case study.

1. Introduction

Traditionally the design activity is based on the use of a CAD system by the designer, who selects the appropriate commands in order to achieve the model of his perception. Although, this approach is used over the years, a number of disadvantages appeared, i.e the final design have limited amount of flexibility in changing the geometry after the CAD model is built, all geometries produced as alternative designs are very similar, the geometries achieved are relatively simple or unusual geometries demanded a great deal of effort from the designer point of view [1].

A step forward was the widespread use of the Application Programming Interface (API) of the commercially available CAD systems for producing general purpose geometries as the basis for product design. A series of standardized products and components are designed with CAD based applications that perform a variety of steps in a limited amount of time and increase the designers’ productivity. The user is able to change a series of parameters from a user friendly computer interface and the rest is delivered automatically from the application [2]. Unfortunately, although this approach is very successful for prismatic geometries and mechanical parts, when it comes to jewellery the automatic design can become considerably harder and as a result computational design pieces of software have been developed and CAD based graphical algorithm editors have been in use [3].

2. Literature survey

A number of research teams dealt with the area of jewellery design from a variety point of view. Stamati and Fudos introduced ByzantineCAD, a parametric CAD system for designing pierced medieval jewellery. The design is implemented by selecting a series of parameter and constraints. The methodology is based on the use of voxel oriented feature based CAD principles. An additional characteristic of the proposed methodology is that the used algorithm, enlarges the designs without altering the size of the elementary structural elements [4]. Goel et al. worked towards the recreation of
traditional Indian ornamental designs via computer aided geometric modelling. These patterns are very suitable for computer based applications. The main aim was to develop computer algorithms that would be able to design Indian jewellery automatically and thus to dramatically reduce the time needed for such a work in the traditional manner [5]. Parsricha and Greeninger applied zero-waste principles via 3D printing with an aim to achieve sustainability in the fashion industry. A number of CAD based applications were used together with 3D printing hardware and software in order to create their designs. Design thinking principles were used with biodegradable materials and both fashion and jewellery products were produced with success [6]. Thammachote et al. studied the development of a new gating system for achieving complete filling in casting of silver jewellery. The proposed shape and dimensioning were investigated using computational modelling and optimal solutions were achieved. Then a series of experimental work was performed in order to validate the simulations presented, thus casting defects were drastically reduced and at the same time the process was extremely productive [7]. Grobman et al. presented a case example for the efficiency of procedural shape modeling in for the mass customization of wedding rings. The current implementation of wedding rings implementation is integrated into the REx system which is based on the GML browser plugi [8]. The present paper aims in providing a systematic way in order to design jewels based on the principles of computational design. According to Grobman the idea of using early stage simulation for form generation, which inverse the traditional design process, tries to integrate numerous developments in jewellery design practice. The idea is not only to provide an automatic tool for the design activities but an integrated tool that will design customized products for each customer, while at the same time a number of alternatives can become available. Those alternatives offer a family of products with minimum effort from the designer, while the geometry is significantly unusual.

3. Proposed framework for the jewellery industry

In order to be able to cope with the increasing demands of the jewellery industry for unusual geometrical forms and easy manufacturing processes, computational design principles are necessary together with the extensive use of 3D printing technologies. The inspiration was based on a technical issue such as the lost wax casting process. The geometry achieved reminds of the geometries appearing during lost wax casting i.e long geometries with relative constant section size and increased 3D network-like form.

![Figure 1. The proposed framework for the jewellery industry.](image-url)
Case study: Bracelet

Figure 2 depicts the technical aspects of the inspiration used. It worth mentioning that this is an additional novelty of the presented work because a great deal of research effort is done towards discovering new ways and methodologies to advance the inspiration of the designers. In the present case study, a manufacturing process such the casting inspired the design team to perform the rest of the steps and finish with a completely unusual geometry for jewellery.

| Case Study       |
|------------------|
| Bracelet         |

| Inspiration: Lost wax casting |  |
|------------------------------|---|
| Original model               | Plaster mould removal |
| ![Original model](image1)     | ![Plaster mould removal](image2) |

| Core material | Copy |
|---------------|------|
| ![Core material](image3) | ![Copy](image4) |

**Figure 2.** Conceptual stage for the design development.

From the technical aspects point of view, the CAD based use of graphical algorithm editor was performed via Grasshopper™. It is an editor integrated with Rhinoceros™ computer aided design platform. The idea was to use a .stl file of the customer’s 3D scanned arm geometry (figure 3). Two planes were created in order to provide the start and the end of the geometry to be used in the automated design algorithm. This methodology emphasizes the customization of the proposed jewellery and increases its added value from the customer’s perspective, because he gets a unique product that fits exactly on him. At the same time, the customer gets additional added value for his funds because he invests on his own 3D geometrical characteristics.

Grasshopper™ enables the development of parametric designs via visual programming. All the models generated are digital models within Rhinoceros™ and as a result the software’s export capabilities can be used for downstream applications such as 3D printing. Another advantage of this approach is the opportunity to go beyond and use the RhinoScriptSyntax module, which incorporates capabilities performed within Rhinoceros™ operations. The library of resources available contains the basis for creating geometry, apply commands, manage document objects and develop application methods. All this functionality is using simple Python™ variables and makes the design process more productive.
5. Alternative forms based on computational design approach

Following the proposed approach, a number of parameters were incorporated within the model for increasing the size of the geometrical sections, the size of the gaps etc., while at the same time the basic principles for the customized jewel applies for each customer. As a result, different geometrical alternatives are designed and the customer is able to decide which alternative is more suitable for his taste. Although there is an increased demand for computation power, when the model is built with a large amount of variables and features, the output is designed automatically. The modelling approach offers the capability of a vast amount of alternatives that can satisfy even the most challenging demands from the customer’s point of view.

If someone compares the time needed for such a complicate geometry to be designed from scratch every time there is a demand for change, the proposed methodology and tool offers a quick response and impressive results in a limited time period. When building this family of products that are suitable for customization, the designer is able to offer this flexibility without the need for repeating manually the appropriate steps needed for designing the final product. All these models can be very easily used for downstream applications that support i.e.:

- Fast prototyping with the use of 3D printing;
- High quality manufacturing with the combination of 3D scan data of the customer and the 3D CAD models produced;
- Virtual prototyping using rendering applications in order to promote both the product itself or customer wearing the product;
- Web-based exhibition of all the models for enterprise and designer promotion.
6. Conclusion
A complete framework for designing customized products for the jewellery industry was presented. The emphasis was given towards the design of a bracelet customized to a specific customer after his arm was 3D scanned and the data appropriately processed. In addition, the computational design tool offers the possibility of executing alternative designs for the same customer’s geometrical data and thus offers a great deal of added value. The contribution of this paper aims to update the jewellery design point of view on digital tools usage (i.e. computational design). The proposed methodology and the presented case study depicts the advantages of a new era of CAD based product design that influences not only the automation of the design process but the customization of the products designed via the production of families of products.

References
[1] Tzintzi V, Manavis A, Efkolidis N, Dimopoulos C, Kakoulis K and Kyratsis P 2017 MATEC Web of Conferences 112 07025
[2] Kyratsis P, Gabis E, Tzotzis A, Tzetzis D and Kakoulis K 2019 Int. J. Mod. Manuf. Technol. 11(3) 110
[3] Kyratsis P 2020 Int. J. Mod. Manuf. Technol. 12(1) 82
[4] Stamati V and Fudos I 2005 Comput. Aided Des. 37 431
[5] Goel V, Khanduja D, Garg TK and Tandom P 2015 Comput. Aided Des. Appl 12(4) 457
[6] Pasricha A and Greeninger R 2018 Fash Text 5 30
[7] Thammacht N, Dulyapraphant P and Bohez ELJ 2013 Int. J. Adv. Manuf. Technol 67 797
[8] Berndt R, Schinko C, Krispel U, Settgast V, Havemann S, Eggeling E and Fellner D 2012 Proc. Int. Conf. on Creative Content Technologies (Nizza, France) (Wilmington, USA: Xpert Publishing Services) p 72
[9] Grobman Y and Ron R 2011 Proc. of 29th eCAADe Confernce (Ljubljana) (CumInCAD) p 107