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Application of 3D Technology in Accessories and Fashion Design

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Abstract. This article delves into 3D Printing's multifaceted applications in fashion, emphasizing its potential for intricate parametric designs and personalized clothing, reshaping the industry. The article includes a practical case study demonstrating iLogic's efficient use to automate part attribute determination and conduct comprehensive stress analysis on a 3D-printed keychain.

Keywords: 3D Printing Technology, Parametric Design, Inkjet Printing, Fashion and Textile, Accessories

1 Introduction

3D Printing, a CAD/CAM technology, creates objects layer by layer from digital models, offering cost-effective and sustainable production. It involves pre-processing (design and layering) and post-processing (finishing) stages, utilizing materials like PET, PA, ABS, PLA, and methods such as SLA and FDM in textile and fashion manufacturing [1].

Parametric design, driven by digital technology, is gaining popularity across various fields, including architecture, fashion, and industrial design. Combining parametric design with 3D printing is recognized as a powerful method for creating intricate structures and fostering creativity. Many studies have successfully applied 3D printing to realize parametric designs in sculptures, apparel, and fashion accessories [2].

The integration of iLogic into Autodesk Inventor elevates the realm of 3D modeling by introducing rule-based computational capabilities. This article delves into a practical application of iLogic, showcasing its ability to imbue designs with sophisticated intent. In focus is the management of "Gjeresia," a crucial parameter; iLogic ensures it falls within specified bounds, generating correction messages when necessary. Furthermore, this study examines the structural aspects of a 3D-printed keychain, crafted from PLA Plastic with precise material properties. Using Autodesk Inventor 2022, Finite Element Analysis reveals critical insights into stress distribution, displacement, and safety factors, ultimately ensuring the keychain's robustness and reliability.

2 Literature Review

3D printing, or additive manufacturing, is a method of creating objects layer by layer using digital models and various materials. This technology offers sustainability and cost advantages over traditional manufacturing methods. Chakraborty et al. [1] introduce a model known as Fused Deposition Modeling for 3D printing in textile and fashion applications. The article thoroughly explains the 3D printing process, comprising pre-processing and post-processing phases.

Jeong et al. [2] emphasize the increasing importance of 3D printing in the fashion industry, highlighting its ability to enable intricate parametric designs. They discuss the fusion of design and programming, the need for education in 3D printing-based fashion design, and the development of various 3D-printed fashion products. Additionally, they showcase examples of parametric fashion designs inspired by nature and organic structures, illustrating the creative possibilities arising from the integration of technology into modern fashion.

Fanglan et al. [3] explore how the combination of 3D printed clothing and big data analysis is transforming the fashion landscape. They describe how designers utilize a comprehensive database of 3D printed elements to create personalized clothing, aligning with consumer preferences and shaping fashion trends. The study also explores the expansion of 3D printing into accessories such as bags, shoes, and hoodies, highlighting both style and functionality. Furthermore, the authors emphasize the potential of personalized advanced customization, guided by big data insights, to produce clothing perfectly tailored to individual preferences and body shapes, influencing the future of the fashion industry.

Chakraborty et al. [4] delve into inkjet printing as a popular 3D printing technique for creating objects through layer-by-layer material deposition. They explain the thermal drop on demand (DOD) ink jetting method, involving the use of heat to create bubbles in liquid ink, propelling ink droplets through a microscopic orifice in the print head. The materials used in inkjet printing, including reactive diluents and support materials, are discussed, emphasizing their thermal stability and ease of removal. The inkjet printing process involves depositing building and support materials layer by layer, typically using photopolymers. The benefits of this technique, such as not requiring volatile solvents, are highlighted. The paper also mentions applications of inkjet printing in fashion and textiles, including the creation of garments and accessories with textured and flexible features, as well as its use in electronic textiles for printing sensors or circuits on fabric.

Shahrubudin et al. [5] explore how 3D printing is reshaping the retail industry, with a focus on shoes, jewelry, consumer goods, and clothing production. Major companies like Nike, New Balance, and Adidas are actively mass-producing 3D printed shoes for athletes and custom shoe enthusiasts. Beyond footwear, 3D printing is revolutionizing fashion design by enabling the creation of unique shapes without the need for molds, simplifying garment and ornament production. This technology also extends to leather goods and accessories, including jewelry and watches. Retailers and designers are keen on offering personalized products, capitalizing on the advantages of 3D printing such as customized fit, cost efficiency in the supply chain, and rapid small-scale production.

In their study, Zangheri et al. [6] provide details on the fabrication of a 3D-printed smartphone accessory and LFIA cartridge using a Makerbot Replicator 2X printer. Specifically designed for a Samsung Galaxy SII Plus smartphone, this accessory incorporates a lens and housing to accommodate the LFIA cartridge, effectively minimizing ambient light interference. The LFIA cartridge is a complex assembly with multiple components, requiring it to be printed in two separate parts and subsequently assembled. The authors also investigate the effectiveness of the smartphone's camera compared to a traditional laboratory imaging instrument, the Night OWL LB 981 luminograph, with a focus on detecting Chemiluminescence (CL) signals from LFIA membranes. In summary, this study highlights the development of 3D-printed accessories aimed at enhancing smartphone-based LFIA assays and presents a comparative evaluation of their performance against a laboratory-grade instrument.

Parametric design (PD) means the use of a CAD system to automatically modify a design as the values of the parameter change and to make corresponding changes to the CAD model during the design process [7]. Given a design problem, the requirements are transformed into a set of parameters and their constraints are also represented via a series of mathematical or logical relations in a hierarchy manner, capturing the product’s behaviors and the structures [8]. As the design progresses further, parameters are introduced describing the dimensions of the object and potentially physical properties to be used for its construction. Therefore, PD offers potentials in quickly design solution generation in terms of the requirements and also maintains the design history steps to create variable CAD models instead of keeping only the one outcome model [9].

Shabani et al. [10] discuss the diverse applications of 3D digital measurement technology, covering dimensions, displacements, and deformations of various parts. They emphasize the technology's relevance in fields such as additive manufacturing and its potential for integration with advanced manufacturing processes through a digital chain. They highlight the primary use of 3D digital measurement for dimensional checks, especially in complex parts, and provide visual examples of these applications. Additionally, they mention special requirements for dynamic measurements, exemplified by the measurement of 3D vibration displacement in a car door. Another important aspect discussed is the measurement of part deformations, with examples of 3D deformation analysis and testing of a 3D printed suitcase handle button.

3 Case Study

In this section, I've described a code designed to determine part color, material, and other variables based on user input values. Additionally, it conducts stress analysis on the designed part, which has also been 3D printed.

3.1 iLogic of the Designed Part

iLogic extends the computational capabilities within Inventor to include rules.
These rules work along with the parameter update mechanism of Inventor, and allow us to include much more sophisticated design intent into our models. A written code manages "Gjeresia": below 60, it's set to 60 with a correction message; above 75, it's

set to 75 with a correction message. Different values are assigned to properties like "Gjatesia," "Trashesia," "Shkronjat," "Diametri," "Material," and "Part Color" based on "Gjeresia" ranges (60-65, 66-70, 71-75).

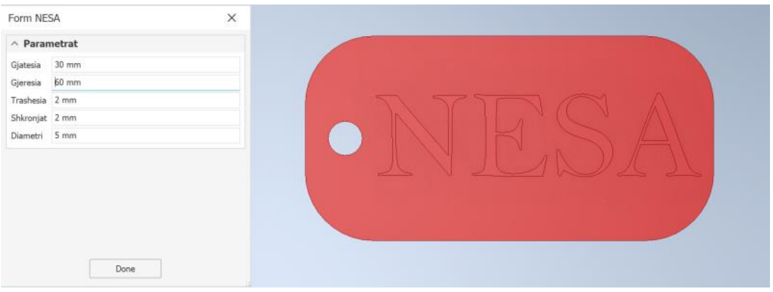

Fig. 1. The result we will have when the “Gjeresia” values are greater than or equal to 60 and less than or equal to 65 (Material: ABS Plastic, Color: Red)

Fig. 2. The result we will have when the “Gjeresia” values are greater than 65 and less than or equal to 70 (Material: PLA Plastic, Color: Dark Grey)

Fig. 3. The result we will have when the “Gjeresia” values are greater than 70 and less than or equal to 75 (Material: Aluminum 6061, Color: Silver)

3.2 Stress Analysis

To analyze "Stress Analysis," Autodesk Inventor 2022 software was used. In the drawing, we can see a keychain, which was 3D printed using PLA Plastic material with the following specifications: Behavior: Isotropic, Young's Modulus: 2.91 GPa,

Density: 1.29 g/(cm^3), Yield Strength: 38.00 MPa, Tensile Strength: 47.20 MPa.
For Finite Element Analysis, it was necessary to fix a surface. In this case, the base surface was fixed, and a force in the direction of the Fx axis with a value of 15 N was applied. It's important to note that this keychain will never bear a weight greater than 1 kg (9,8 N), but for analysis and safety considerations, a higher value was considered. From the conducted analyses, the following observations can be made:
Von Mises Stress: The minimum stress in the part is 0 MPa, while the maximum stress in the part is 1.104 MPa (Fig. 4).

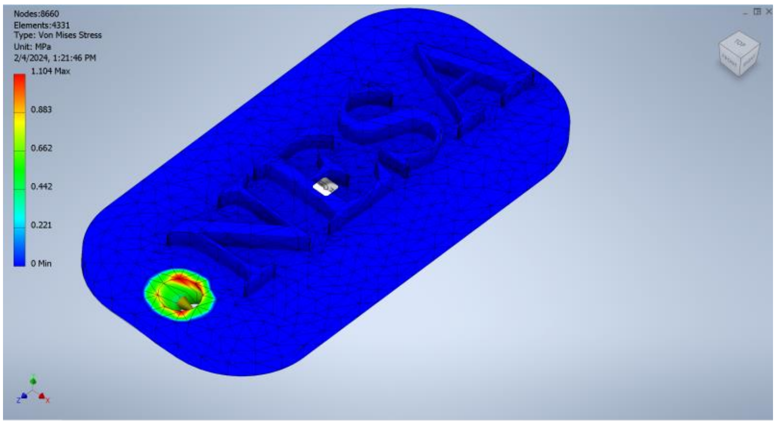

Fig. 4. The minimum and the maximum stress on the part (1.104 MPa – Max and 0 MPa – min)

Displacement: The maximum displacement in millimeters is approximately 3.9e-04 mm, which is nearly negligible in practical terms (Fig. 5).

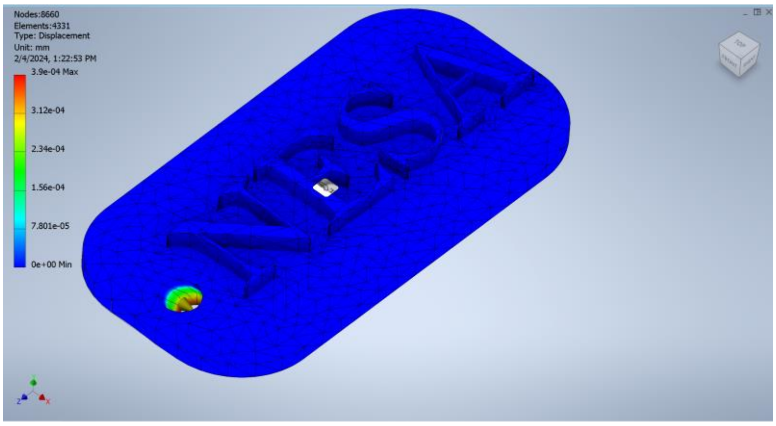

Fig. 5. Displacement (3.9e-04 mm – Max)

Safety Factor: The maximum safety factor is 15, while the calculated safety factor is approximately 3.5. This indicates that the model is approximately 3.5 times more stable than the current applied load (Fig. 6).

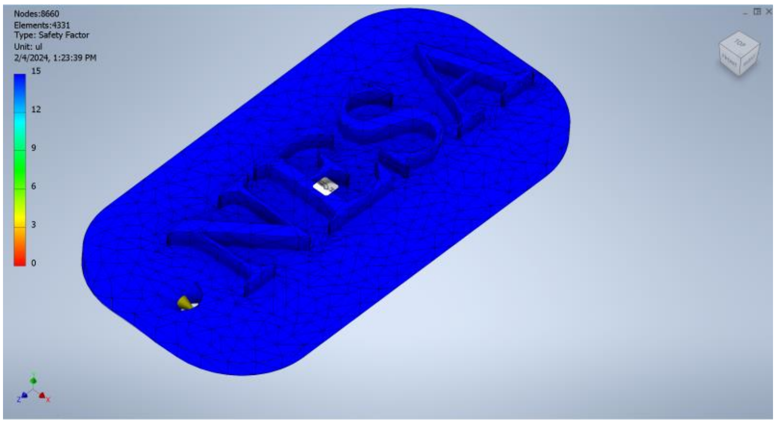

Fig. 6. Safety Factor

As mentioned earlier, this keychain has been 3D printed (Fig. 7).

Fig. 7. 3D Print of the Keychain

4 Conclusion

This article explores the various applications and implications of 3D printing technology in fields such as fashion, manufacturing, and digital measurement. It also delves into the practical implementation of 3D printing using iLogic in Autodesk Inventor, showcasing its ability to automate part attribute determination based on user input, which will enable users to print their own designs. The integration of iLogic in 3D printing processes is a significant step towards making 3D printing more accessible and user-friendly, and it has the potential to revolutionize the way we design and manufacture products. The stress analysis on the 3D-printed keychain provides crucial insights into structural integrity and safety. The results indicate a well-designed and stable model, with Von Mises stress, displacement, and safety factor analyses offering valuable information for ensuring reliability in 3D-printed objects.

Appendix A. Parameters in iLogic. Gjerësia-Width, Gjatësia-Height, Trshësia-Thickness of Base, Shkronjat-Thickness of Letters, Diametri-Diameter.

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