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Designing Movable Chain like Structure with 3D Modeled Elements

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Introduction

3D printing is still considered a futuristic technology, although the first concepts of 3D printing appeared in a science fiction story "Things Pass By" by Murray Leinster in 1945. (Turney, 2021). In the textile field, 3D printing is used in three forms: 3D printing directly on textiles, 3D printing of flexible structures, and 3D printing with elastic materials. Different printing technologies are used for all three forms.

Flexible 3D-printed structures that simulate textiles can be produced using three different methods (Sitotaw et al., 2020): in the first method, called "mesostructure", the individual elements of thin layers or sheets are aligned perpendicular to the base surface, which allows them flexibility in different directions. The second method is based on a patterned structure of many precisely designed and modelled triangular panels connected by hinges. While each element is rigid, when they form an entire dress, they behave like a continuous fabric that conforms well to the body. The third method is based on connecting rings (Bingham and Hague, 2013) or other closed elements. Each ring has enough space to move freely, which allows good draping around the body.

Aim

The goal of our research was to create various chain-like structures (third method mentioned above) that mimic a textile structure. They should be movable and able to adapt to the object of collision for different purposes, such as making a dress, a fashion piece, or an accessory. During the design process we 3D modelled chain elements derived from Celtic knots, which were virtually assembled into a chain-like structure to create interesting mesh patterns.

Methods

Various steps were set for the design process as shown in Figure 1. We modeled the structures in the 3D program Blender. In the test part, we established the method, which was verified during further development and design. This was followed by the design of individual elements inspired by Celtic knots (Figure 2), although the starting point for each design of the element was different. Afterwards all the resulting textile-like structures were assembled.

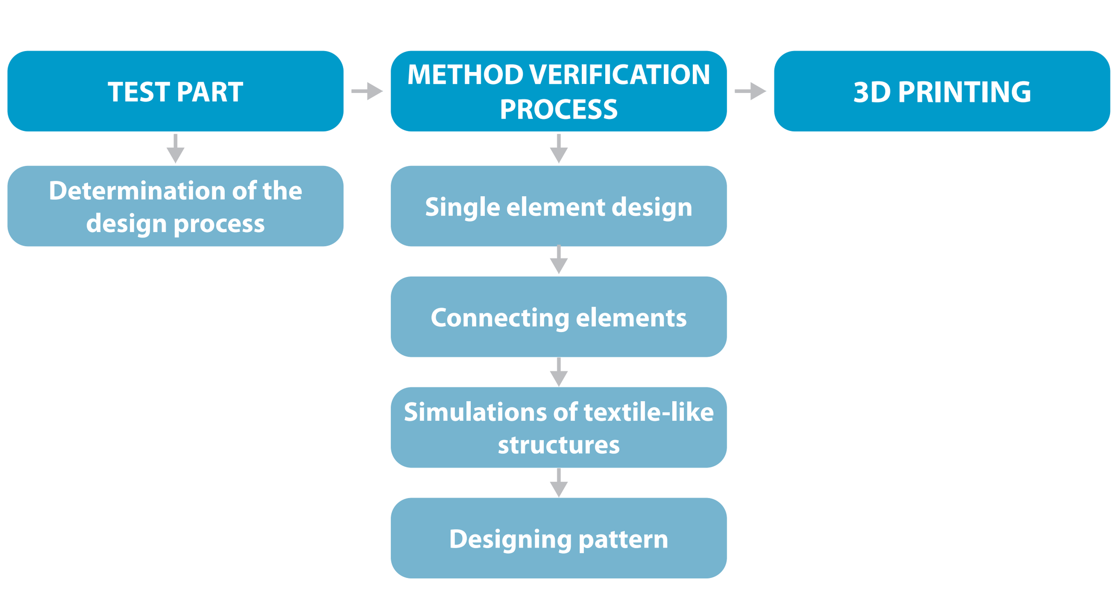

Figure 1

The scheme of the design process of chain-like structures

First, the elements were assembled into one chain, which was then multiplied to the desired size. By simulating the fall of meshes onto a collision object we observed the behaviour and movement of the designed textile-like structures on various collision objects (Figure 3).

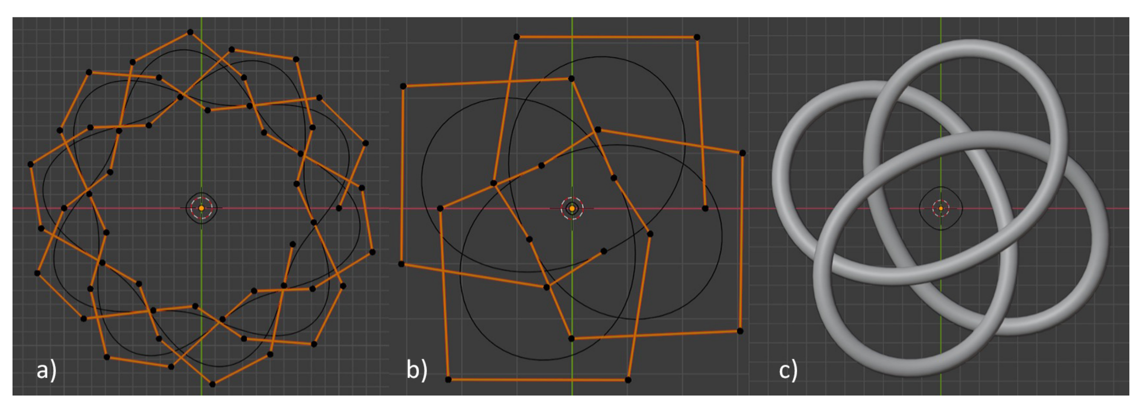

Figure 2

a) Initial geometry of Dara knot, b) Remodeled geometry, c) 3D model of the knot

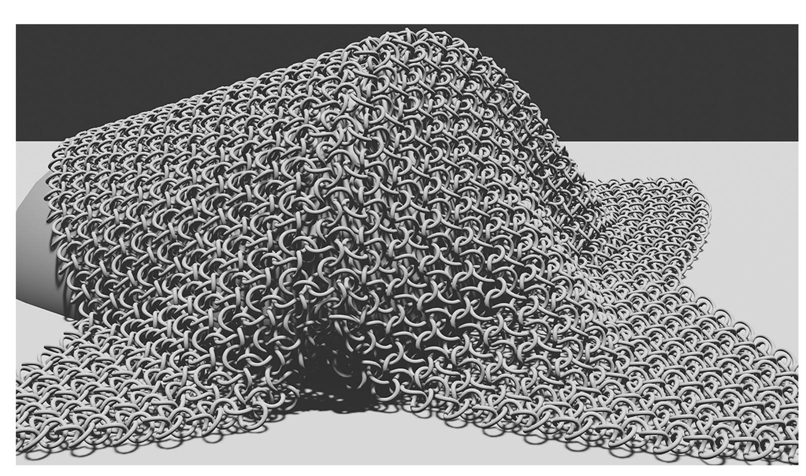

Figure 3

Simulation of Salomon's knot textile-like structure on an object

The 3D printing attempt refers to the test part, where a part of the torus mesh was printed with printer FormLabs Form 2. Printer supports SLA technology and allows high precision and quality print as well as easy preparation and maintenance. The purpose of 3D printing was to check the flexibility and the strength of the textile-like structure and to find out the appropriate size of each element (Figure 4).

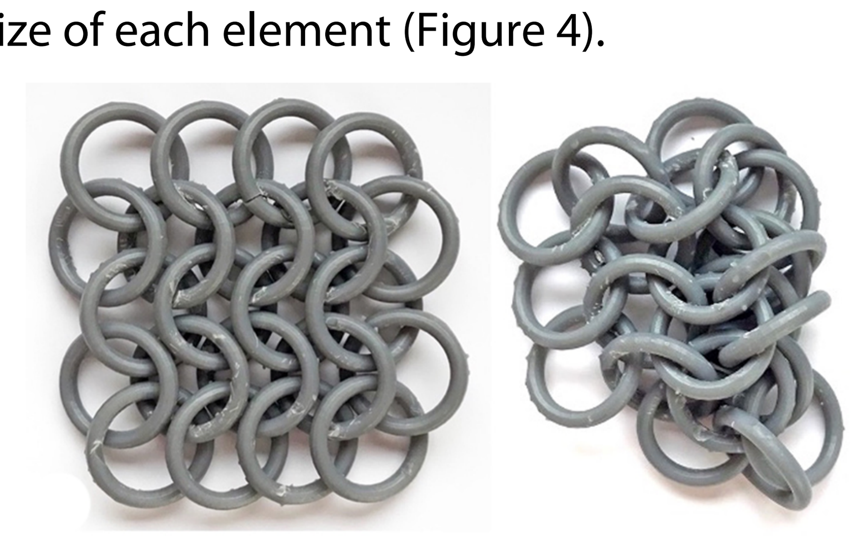

Figure 4

3D printed part after removing support structures

Results / Discussion

The 3D printing process has shown that the textile-like structure can be movable, even if it consists of rigid elements. The spacing between the elements is very important because it allows the chain-like object to be flexible. In the design process visually interesting patterns were created when we put together different shapes and sizes of elements. In addition, even more interesting patterns were created when color was added (Figure 5 and 6). The use of 3D textile-like structure simulations on a human body as a garment is shown in Figure 7. However, the use of "plastic" materials in direct contact with the skin as everyday clothing is still an open area of research, as the materials do not yet allow such comfortable clothing to be produced.

The textile-like structure created could be used to make handbags, lampshades, and other decorative objects or accessories.

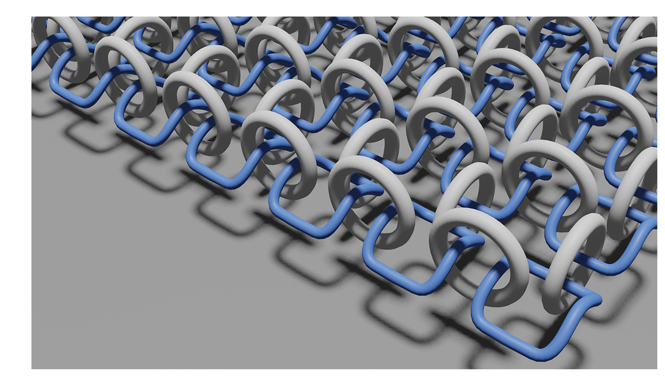

Figure 5

Rendered pattern of Tori connecting elements of the Endless Knot

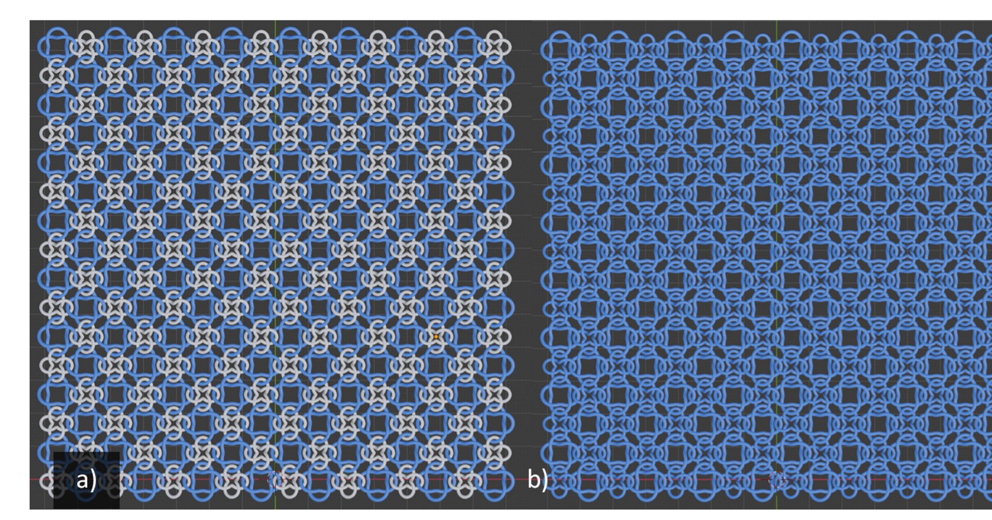

Figure 6

Solomon's Knot pattern: a) Blue-white and b) Monochromatic pattern

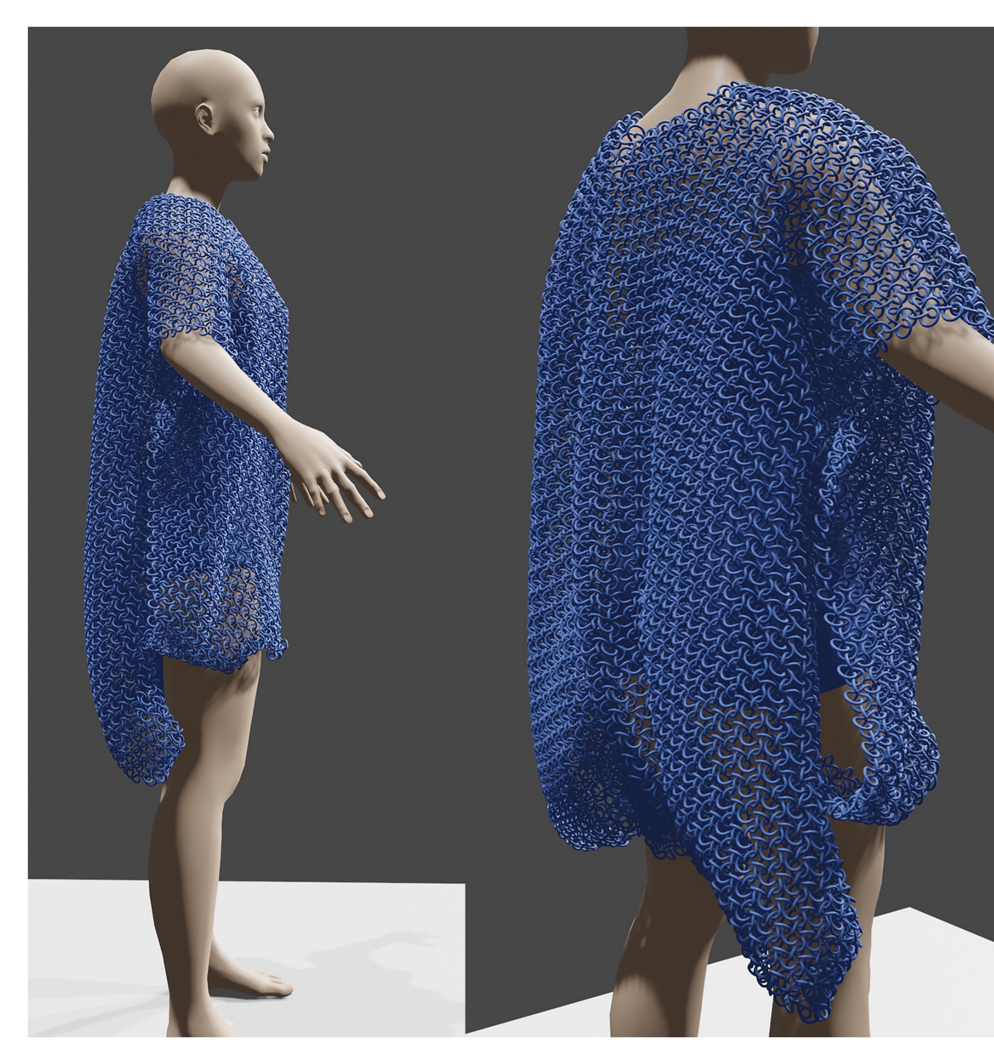

Figure 7

Final render of textile-like structure on human body

Discussion / Conclusion

Throughout the process of modeling, simulating, and realistically rendering the textile-like structures, we learned that the individual elements must be considerably small and dense to create the chain-like material that is movable and drapes similarly to a textile. More interesting structures were also created by putting elements of different shapes and sizes together and then adding them colors to create patterns. Furthermore developments in various areas of creating textile-like 3D structures are possible, whether in terms of structure, materials, or color.

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