Parametric Harmony

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Introduction/Concept/Context: As a popular design concept, parametric design has been used in various industries, especially in architectural fields. The term "parametric" comes from mathematics and involves using specific parameters that can be adjusted to change the outcomes of equations (Frazer, 2016). With the advancement of digital technology, developers created parametric design software such as Autodesk Maya and Grasshopper for Rhinoceros in the early 2000s. These tools offer various plugins across multiple disciplines, enabling designers without formal scripting backgrounds to easily generate complex parametric forms (Eltaweel & SU, 2017). Architect Zaha Hadid, known for her dynamic and organically shaped buildings, used parametric equations and algorithmic computational thinking to push the limits of architectural design (Link, 2021). Similarly, fashion designer Iris Van Herpen utilized parametric design and 3D printing to transform computer designs into futuristic wearable art (Team, 2023).

Parametric design methods enable designers to generate countless designs with just a few adjustments to existing models (Myung & Han, 2001). This principle aligns with modular design, where detachable or replaceable components allow for infinite design combinations (Koo et al., 2014). However, literature reviews reveal few examples of parametric design methods used in modular garment designs. Additionally, existing modular concepts done by fashion designers often result in flat interlocking units that limit shaping and body contouring (Stam & Eggink, 2014; Mini, 2009; Chen & Lapolla, 2021). Previous designs by the fashion designer have explored modular design to create fitted silhouettes by incorporating different scales of modules (Chen, 2019). However, the process is time-consuming due to manual calculations. For this design research, the fashion designer collaborated with an architect to explore the potential of 3D digital technology to produce fitted and sculptural modular design using parametric design methods and 3D printing. This collaboration merges architecture and fashion to produce intricate wearable structures powered by computer algorithms and parametric modeling.

Aesthetic Properties and Visual Impact: Inspired by organic lines and forms found in nature, this design explores how digital technology is changing our relationship with nature. In the book *What Technology Wants* (Kelly, 2014), the author suggests that technology is essentially an extension of the same forces that drive life, viewing it as a natural system and an extension of biological evolution. By simulating complex patterns observed in nature to fit the human body through both 3D printed modules and 2D digitally printed fabric, the dress creates a strong visual impact from all angles, featuring curves and sculptural shapes made possible through parametric modeling. This design combines elements of fashion and architecture, nature and technology, parametric design and modular design, suggesting a harmonious and collaborative future.

Process, Technique, and Execution: The process began with conceptual exploration for both the silhouette and module designs. Fashion sketches were first created by the designers based on inspirations. The sketches were then be visualized in Autodesk Maya for 3D modeling. By utilizing the 3D modeling tool, the fashion sketch was accurately built in proportion on the digital avatar for design visualization. The two designers worked together in Autodesk Maya to finalize the design. Fluid seamlines were added to the design to create more dramatic pattern shapes, while a 3D sculptural hood inspired by floral geometry was built on the back of the dress (Figure 1). Next, to model the curved and fitted pattern shapes into modules, a computer algorithm was developed using Grasshopper, which is a parametric design plugin for Rhino.

During the modeling process, the dress model from Autodesk Maya was transferred into Rhino and Grasshopper to generate the 4-sided module shapes with interlocking details for connecting to each other (Figure 2). Once the flat 4-sided modules were successfully generated on the dress with the avatar, they were parametrically laid out flat and packed tightly next to each other in Rhino to be exported to a 3D printer. There was a total of 147 module pieces. Numbers were generated automatically with Grasshopper on the back of each module for easy sorting and assembling. The 3D sculptural module used on the hood of the dress was also originally modeled in Maya and then proliferated parametrically using Grasshopper. Finally, FDM 3D printers were used to print all modular pieces using a white TPU filament.

Figure 1. 3D modeling in Autodesk Maya.

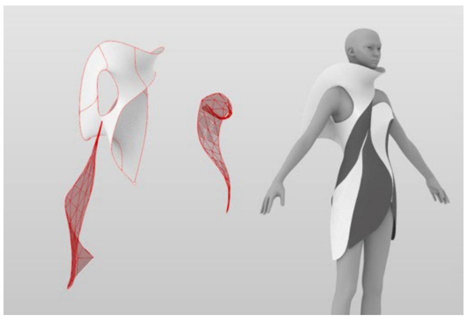
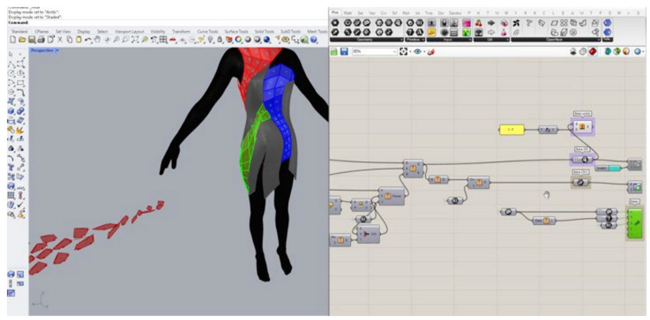


Figure 2. Generating modules in Grasshopper.



For the fabric component, the pattern shapes from Autodesk Maya from previous steps were transferred into a CLO file to draft the pattern pieces for the dress in CLO. The digital prints on the fabric were simulated digitally in Grasshopper using the Differential Growth algorithm. This algorithm, which is found in nature in the growth processes of certain plants and corals, was mathematically recreated by scientists as a close approximation of that natural growth pattern (System, n.d.). The 2D line pattern generated in Grasshopper was then augmented and amplified with Adobe Photoshop to achieve a 3D visual effect by incorporating shadows, depth, and highlights. Finally, the rendered line patterns were placed on the CLO-drafted pattern pieces and digitally printed on polyester chiffon and polyester satin fabric. A connection module, also 3D printed with TPU filament, served as a closure to join the 3D printed modules and digitally printed fabric. The final fabric components were made with two layers of digitally printed fabrics, with the 3D printed connection modules sewn at the edges of the fabric pieces. A short video of the design process is available to view here.

Cohesion: The application of parametric design in wearable art significantly facilitates a complex creative production and optimization process. It began with a conceptual vision, where both the fashion designer and architect visualized the shape, function, and aesthetics of the garment design using digital parametric modeling tools. 3D printed modules were tested to interact with parametric structures, and the design integrated these modules with digitally printed fabrics featuring dramatic patterns, ensuring the garment moves harmoniously with the body.

Design Contribution: This collaborative design research demonstrates how parametric design methods enable designers to efficiently create intricate and dynamic modular designs. The design can be easily adjusted using computer algorithms and parametric modeling, fostering creativity in form and structure, which is essential for creating wearable art (Jeong et al., 2021). By combining 3D modeling and parametric design software, the designers created highly customizable modules tailored to a person's body type and significantly sped up the process compared to traditional methods by using computer algorithms. This piece contributes to the existing body of knowledge on parametric design methods in modular design using 3D printing technology. Future research will explore more complex wearable art with parametric features.

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