

Flexible and Reconfigurable 3D Printed Garment with Heart Beats

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The purpose of this experiment is to produce a versatile 3D printed garment made of 3DP textile that has a similar stretch characteristic to that of knit fabric by applying many zigzag lines with heart-shaped patterns using TPU (thermoplastic polyurethane) filament. The inspiration of the 3D printed textile pattern comes from heartbeat pulses and Andreas Bastian's mesostructured method that allows a degree of flexibility not typically possible with PLA (polylactic acid) filament (Adlughmin, 2014).

The pattern has many repetitive heart-shaped images connected with zigzag lines, which represent heart rhythms. The textile is printed with elastic and flexible TPU material, which is smooth to the touch, but at the same time extremely durable and strong with a sheen look. Unlike the rigid properties of PLA and ABS, TPU is the most suitable filament for producing 3D textile like surfaces with flexible characteristics (Tolmaç & İşmal, 2023). The width and length of the hearts are about 1.5 to 2 cm. The width of their overall wall is 1 mm with its height 2 mm. The height of the pulse shapes that link together ranges from 1.5 to 1.75 cm. The zigzags increase the textile one-way stretch by 25%. The hearts function as connectors between the pulses.

Despite their potential, 3DP garments still face certain limitations. The printing process can be time-consuming, making it challenging to produce garments at a large scale. Moreover, the current state of 3DP technology and materials can be prohibitive for mass production. The comfort and breathability of the garment need further improvement.

Many researchers and fashion designers are exploring the possibilities of 3DP garments. They are experimenting with various techniques, such as integrating flexible materials, incorporating smart textiles, and exploring new printing methods to overcome the limitations and push the boundaries of fashion design (Čufer, Čuk, & Kočevar, 2022) and (Xiao & Kan, 2022).

The 3DP red and black fitted outfit has a strapless crop top and short skirt with an undergarment stretch top and skirt for a versatile look. The princess seam-lined top has a decorative necklace, and the center bottom tip of the necklace is attached to the center front neckline. The necklace has many columns of 3DP red and black hearts linked together with small red jump rings. The fitted short skirt has a princess seamed design as well. The center front and back panels of these pieces are red, and the side panels are black. Moreover, there is another accessory added to this silhouette – a belt with several rows and columns of black and red hearts linked together with jump rings. Half of the belt is red, and the other half is black. The red color of the 3DP garment set represents life, health, and love; the black one signifies symbols of sophistication and elegance.

Furthermore, a two-piece ivory-colored stretch undergarment, the strapless fitted top and skirt (with black mesh on the bottom section) are added to the 3DP garment. They are worn under the 3DP garment to show visibility of the design details, improve comfort, conceal parts of a body,

and offer versatility of the design. The undergarment material is compatible with the 3DP textile because they have about the same stretch ratio. To hold the 3DP top and the skirt when wearing with the undergarments and keep them together as a unit, small snaps are sewn on both sides of the skirt waistline and neckline.

The full set of the 3DP garment with its undergarments offers versatility in design permutations. For instance, one can wear them with many choices of design looks either with the belt or not. First, the two undergarments can be worn with both the 3DP top and skirt. Second, the strapless top can be paired with the 3DP top and its underskirt only. Third, the underskirt skirt can be paired with the 3DP skirt and its strapless top only. Moreover, when adding the 3DP belt to all 3DP tops and skirts above, each of the appearances will be converted to a dress with a different look. When wearing the belt, one can select a red, black, or combination of both colors. In total, there are eighteen possible design combinations that can be created with the pieces described here.

The process of creating the textile begins with importing a heart image in jpeg format to Rhinoceros software. I traced and outlined a heart shape. Once the outer line is completed, an inner closed line, which is 1 mm away from the outer line (for the thickness of the heart wall) is created. Then, a 3D image of the heart with its height of 2 mm is formed by extruding the closed shape. To make sure the 3DP heart does not leak when 3D printing, its edge is analyzed by utilizing one of the edge tools from the software.

The second 3D heart is copied from the original one to generate another 3D heart with few pulse lines in it. Afterwards, 3D zigzags are created and extruded to produce a 3D heart shape with pulses. After these two hearts are formed, a chain of 3D zigzags is created and placed under or above the hearts. These two 3D hearts and zigzags are aligned perpendicularly and connected in rows and columns, which provide the textile stretch appropriately.

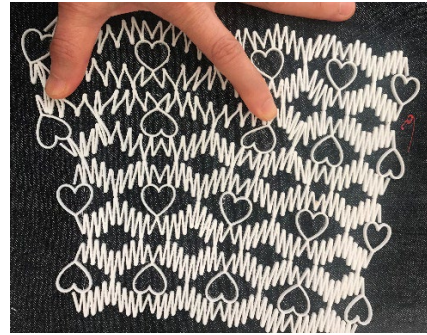
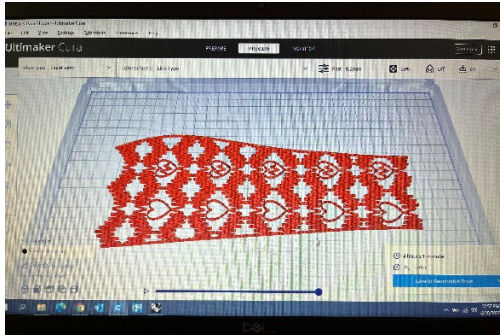
Prior to creating a larger textile and a full-scale 3DP garment, a prototype of a small piece of textile is generated, and a stretch test is performed. As a result, the percentage of one-way stretch is 25%, which is the highest value in the low-level knit stretch category.

The next step is to create the full-scale garment patterns of a crop top and a short skirt for sizes 6 and 8. The width of the paper/muslin patterns need be decreased by 25% due to its one-way stretch, so the dimensions of the 3DP textile for the outfit can be calculated.

Going back to the software, the textile is cut by applying a Boolean split tool according to the shapes of the patterns. Later, a 1 mm wall/seam is added and joined at each of their cut edges, so the edge and the wall join without any leaks when 3D printing.

Once each panel is completed successfully and is ready to be printed, the solid model is sliced in a 3D modeling software prior to 3D printing in a Fused Deposition Modeling, FDM printer. Since the design is intricate using TPU and dimensions of the hearts and zigzags are small, the printing process needs to be at a relatively slow speed. As a result, the completed product is clean and neat. In fact, each panel of this 3DP garment takes about nine hours or more to complete. Once all panels are printed, two seams such as princess and side seams can be fused or glued. The software depiction of the 3DP fabric as well as the resulting stretchable fabric are shown below.

Both accessories, the belt and necklace consist of red and black hearts and link with red jump rings. To fabricate these hearts, the heart shapes are extruded to about 2 mm and one to four small holes are created in these shapes to accommodate the jump rings.



References

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