Then Try This • Algorithmic Pattern Salon

MultiWeave

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Then Try This

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ABSTRACT

Presenting the method of creating textiles, that consist of warp and weft, following the logic of additive manufacturing. The warp loops are temporarily held by vertical supports on a horizontal field and the weft yarns are guided around and between the warp loops forming material layer by layer. When the height of the material has been reached the ends of the warp loops are connected to each other and the textile is removed from the supports. Method has been named "weaving", because it consists of two sets of yarns: vertical and horizontal. The difference from loom weaving comes from the way how warps are positioned on a flat surface so that weaver can change the order of how weft meets warps. The method allows to make structured, 3-dimensional net-like structures. The paper presents the story of how the developing of this method started in hackathons, where working prototypes of computer operated weft guiders were built, how this method of constructing textiles was developed as an artistic craft technique in the Pallas University of Applied Sciences (Tartu, Estonia) and introduces artists and designers who have been working with this technique and developing variations during the period 2016—2023,

Born in Hackathons

When I entered the first hackathon with the idea of a machine MultiWeave (MW) that uses the logic of additive manufacturing (similar to 3D printers) to place weft yarn between vertically supported warp threads then the idea got support from Anna Jõgi with a background in electronical engineering, software development and DIY culture. Anna who has also knowledge of weaving proposed that we should build during the hackathon a CNC machine of our own. DIY sites provided the guidelines of how to build such machines. The first prototype of digitally operated weft-yarn guider MultiWeave was built during 48-hour hackathon (2016) using Arduino, 3 stepper motors and some plywood and drawer sliders instead of lead screws. Our team had only four members and the result was working slowly and with much noise, but we had proven the concept! From the first hackathon our team got the prize of The Best Prototype Implementation[1]. The unconventional situation in hackathons and the spirit of "nothing is impossible" has enabled people with different skills (textile artist, software developer, electronic engineer, mechanical engineer) to work together in the frames of limited time (48 hours) and reach the goal: working prototype (Figure 1).[2]

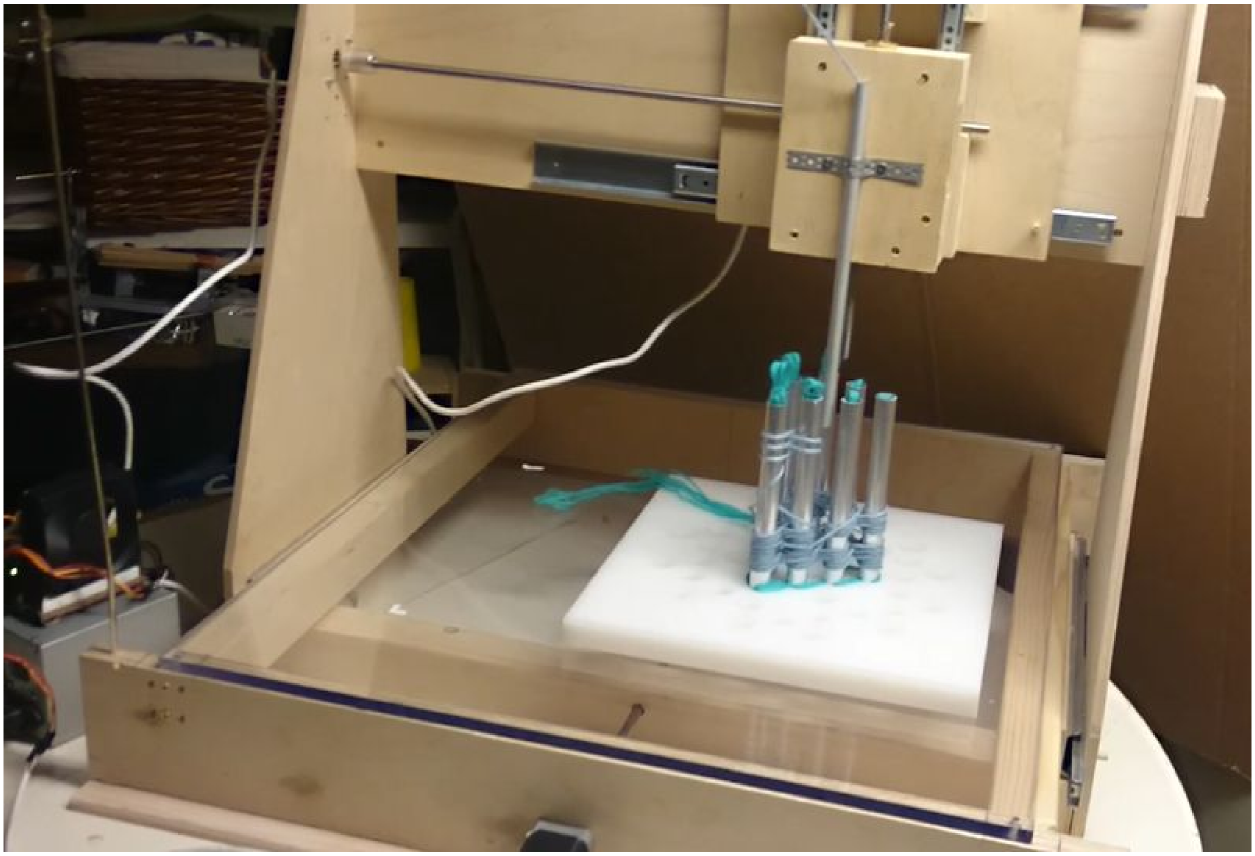

Figure 1
First prototype of MultiWeave machine, built during 48 hours at Skeemipesa Hackathon in 2016 by Anna Jõgi, Oleg Kalinkin, Johan Pajupuu, Kadi Pajupuu. (Photo: Kadi Pajupuu)

Pallas University of Applied Sciences (Pallas UAS) accepted MultiWeave as an applied research project[3] and gave support to develop the user interface and software. Anna Jõgi developed the software so that the user can mark active warps on a field and draw the path of the weft around warps (Figure 2).[4]

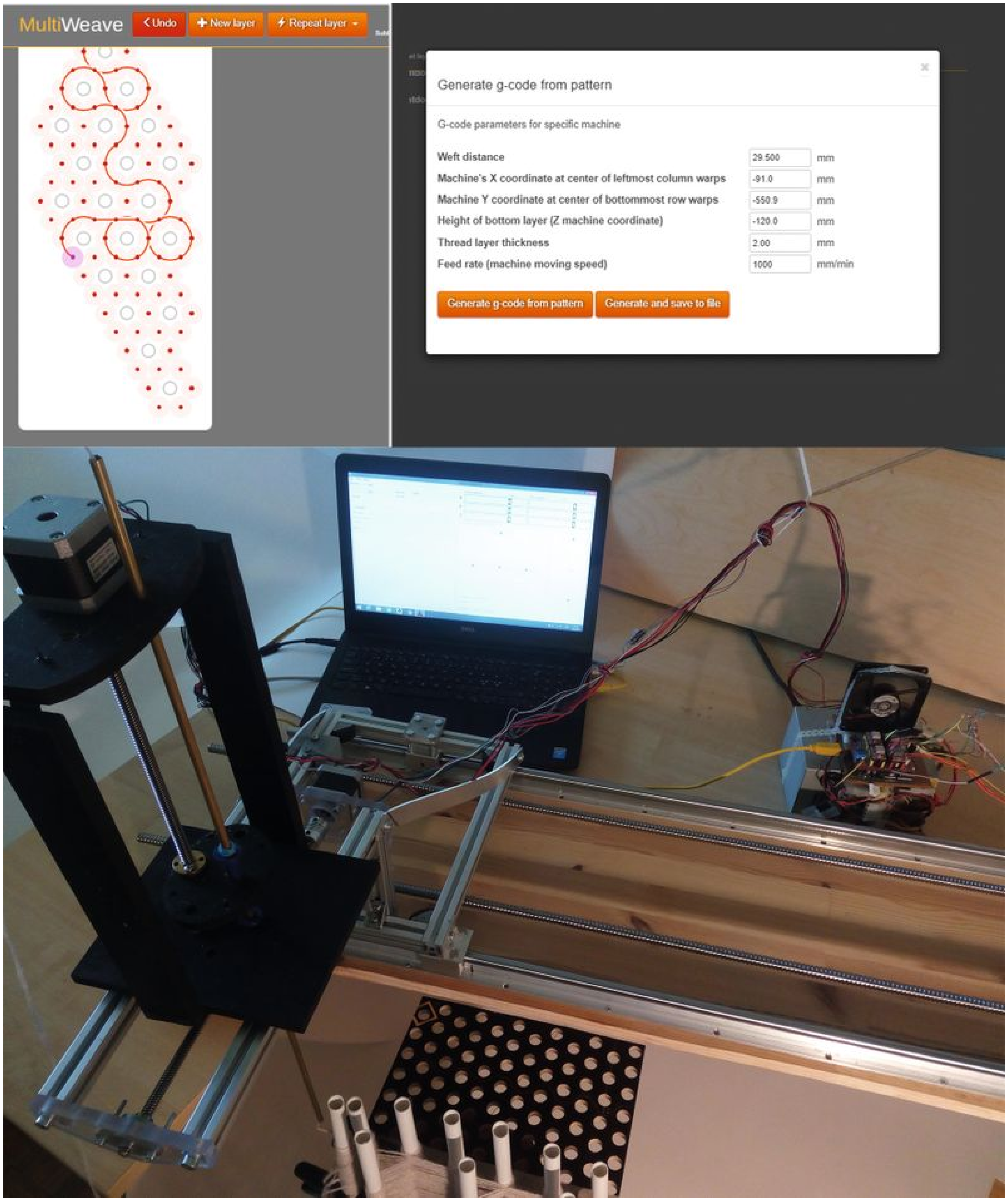

Figure 2

Software developed by Anna Jõgi creates g-code out of the path of the weft drawn by the user. One of the prototypes of MultiWeave machine. (Photos: Kadi Pajupuu)

"There are four key techniques to computational thinking:

- *decomposition—breaking down a complex problem or system into smaller, more manageable parts*
- *pattern recognition—looking for similarities among and within problems*
- *abstraction—focusing on the important information only, ignoring irrelevant detail*
- *algorithms—developing a step-by-step solution to the problem, or the rules to follow to solve the problem*”[5]

In the process of developing MultiWeave the first problem that I identified was that although there have been interesting projects for building 3D material using yarn—for instance by Oluwaseyi Sosanya[6], the 3D printed materials needed adhesive component. I was looking for a way to get rid of the need of adhesives so that the textile material can be made from natural yarns. Peg loom weaving is a primitive way of weaving, where weft yarn is guided around sticks with individual warp yarns attached to those sticks, after some rows of weft the woven part is pushed from the sticks to the warps. I thought that warp yarn should be inside the structure from the beginning. Those vertical supports are attached on a horizontal field in multiple rows and warping is done so that warp yarn forms continuous field of loops. So **decomposition** in my case was that I got rid of the need to push individual warps into weft structure and instead formed multiple rows of warp loops, so the material can be grown horizontally, and the height of the warp supports determines the thickness of the material. And **pattern recognition** thus rooted in the understanding that in 3D printing the material can be guided around rigid vertical elements like also in basket weaving and peg weaving and the rigid elements can act as temporary guides to the weft.

As to “**ignoring irrelevant detail**” it was important not to worry about the looseness of the structure as the distance between the warp supports was determined by the diameter of the tube that acts as a weft guider, and when rigid warp supports were removed from the woven material empty spaces were left that added to the airiness of the structure. When woolen yarn is used, it is possible to strengthen the structure in the washing machine.

Algorithms or **creating step-by-step solutions** to the problems were used throughout the project.

MultiWeave as a “weaving” technique

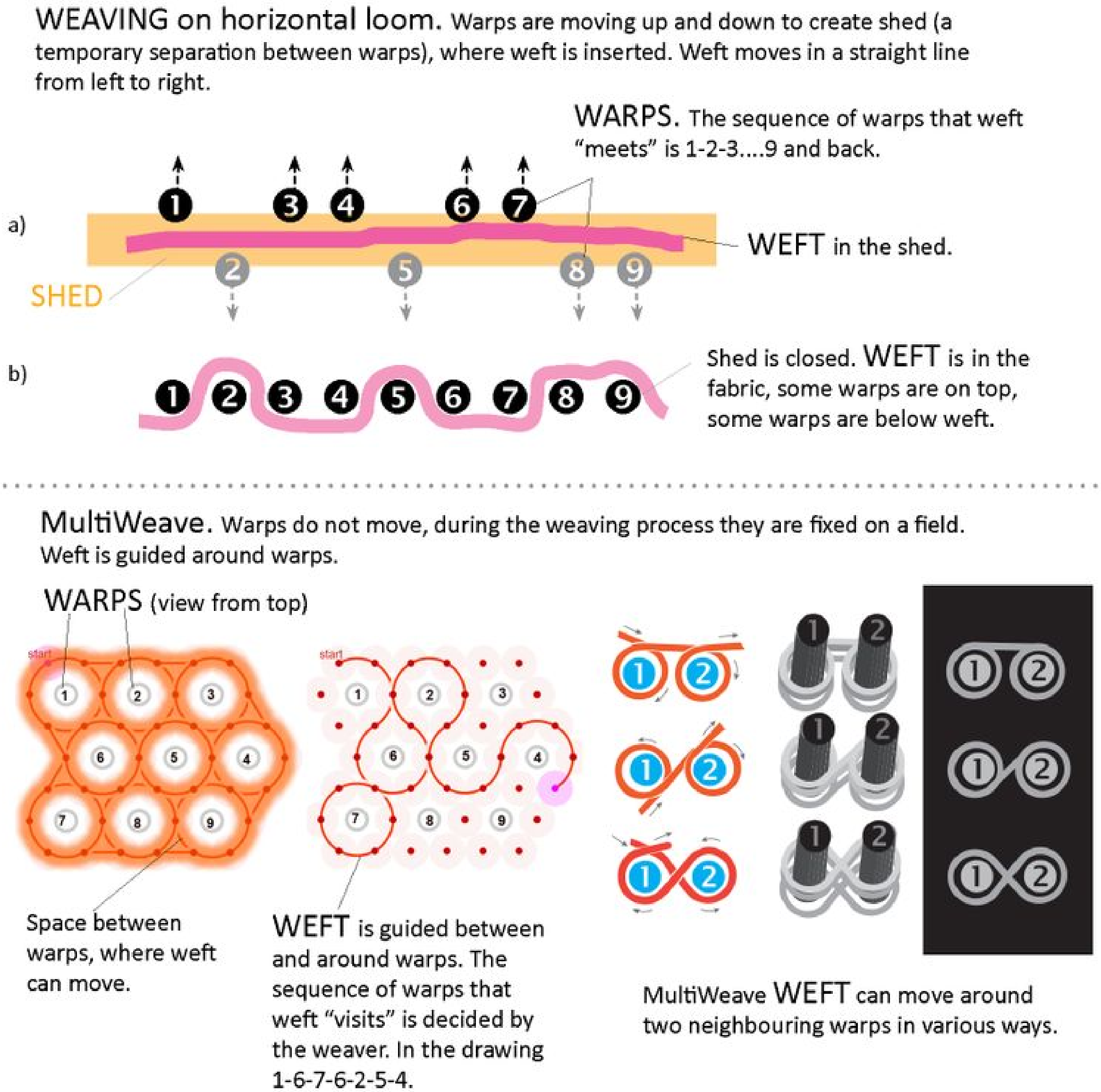

Figure 3
Comparison of weaving on horizontal loom and fabric formation on MultiWeave loom.
(Drawing by Kadi Pajupuu)

How does MW weaving differ from other textiles that consist of warp and weft yarn? What are the pattern possibilities that come with that technique?

a) Movement of the weft yarn relative to the warp yarn. The weft thread can move in a circle around the warp, so you can create a fabric surface with a ribbed structure with just one row of warps. Similar technique can also be used in tapestry weaving or in some carpet techniques: by wrapping the weft yarn around individual warp threads (or warp groups), but in the case of MW, the individual warp threads are only attached from the bottom (whereas tapestry warp threads attach at both the top and bottom), and the weft thread can be quickly guided around the warp loops. (Figure 3)

b) Location of the warp threads in the fabric. Since with MW the warps can be attached to the board in several rows, structural plate material can be woven. The structure is determined by the direction of movement of the weft threads and the way the individual warp thread is grasped (Figure 3). The visual appearance of the MW fabric can also be influenced by how the warp loops are connected to each other; either along the rows in a row or across the rows or by combining the ways warp loops are joined.

c) Changeable fabric thickness. The height of MultiWeave material can be varied, that is, fabric sheets of varying thickness can be woven.[7]

Textile students of Pallas UAS started to explore what kind of patterns/structures can be made manually with MultiWeave technique. The logic of MultiWeave structures is described in Figure 3. The warps are loaded row by row on a field, warp loops are held vertically with the help of rigid temporary supports (not shown in Figure 4), the drawing on the right shows how weft can be guided between and around warp loops: the weft can move following the lines of warp rows or moving diagonally over the field. Also the movement where weft makes a circle around the warp before heading to the next warp (soumak weave) is possible. The thickness of the material (in the direction of warp) depends on how high are the warp supports.

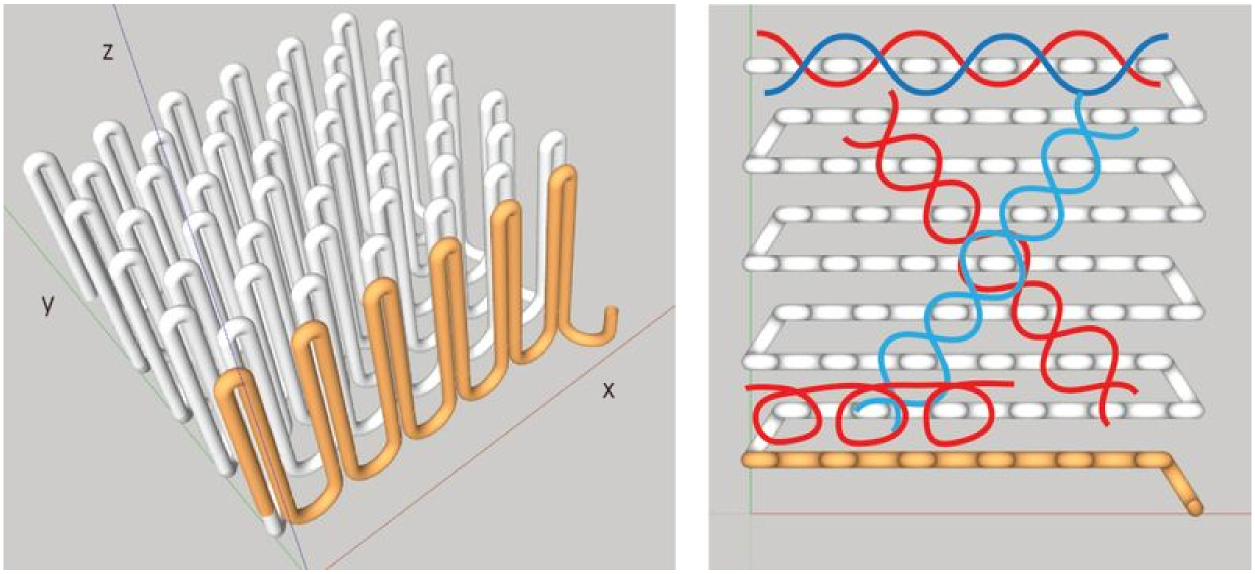

Figure 4
On the left: schematic depiction of the field of continuous warp thread, that forms loops; on the right: view from the top shows how weft yarn can move around and between warp rows. (Drawing by Kadi Pajupuu)

The pattern/structure of MultiWeave material can be determined by the positioning of warp rows in the material (Figure 5).

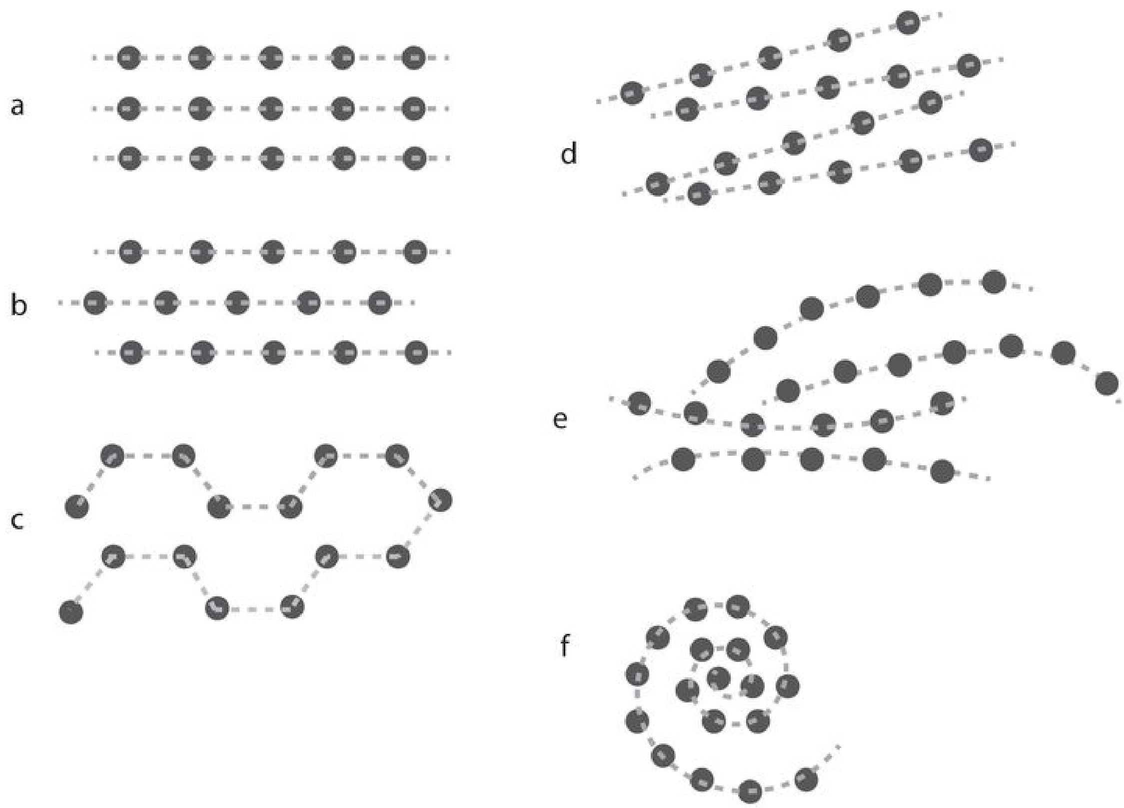

Figure 5
Variations of how warp rows may be placed in the material before the weaving (placing of weft rows) starts. (Drawing by Kadi Pajupuu)

Figure 6
Riina Samelselg. MultiWeave structure 68x. (Photo Riina Samelselg)

Riina Samelselg has woven a MultiWeave work that she named 68x. (Figure 6, 7) The warps were placed in the corners of hexagons and weft was placed so that it formed figure 8. In this work, all the intersection points of the warp and weft are movable and this allows for a visually varied deformation of the elements based on the curvatures of the base surface or support or stretching points.[8]

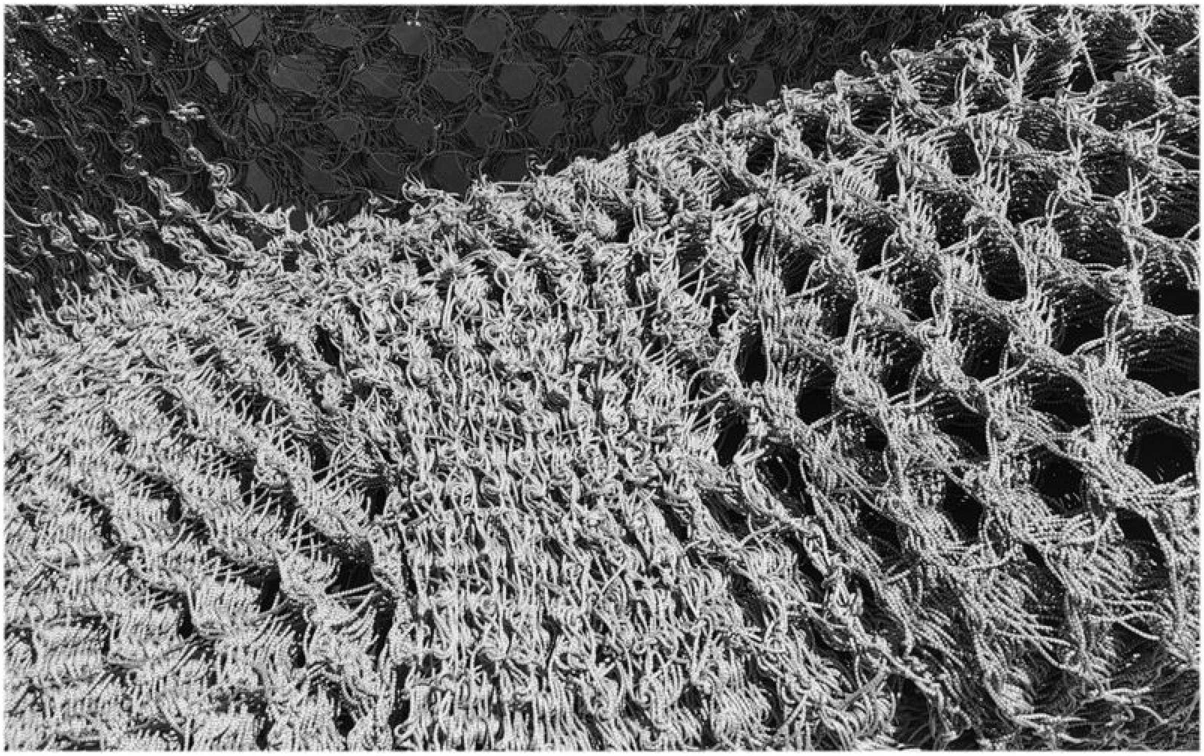

Figure 7
Riina Samelselg. 68x, detail. Photo by Riina Samelselg

Marilyn Piirsalu used the parallel positioning (Figure 5, a) of warp rows. (Figure 8, 9, 10) The way how the work is hanged affects the pattern.

Figure 8
Marilyn Piirsalu. Structure I. (Photo Kadi Pajupuu)

Figure 9
Marilyn Piirsalu. *Structure I*. (Photo Marilyn Piirsalu)

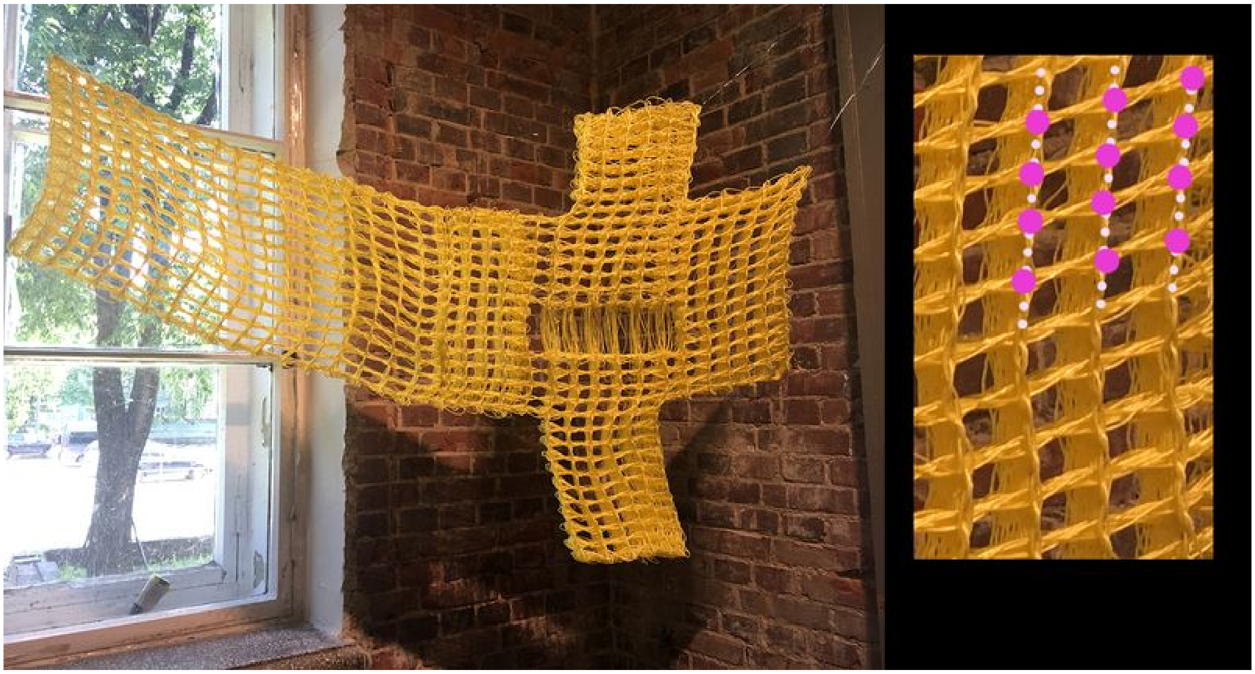

Figure 10
Marilyn Piirsalu. *Golden*. Warp thread rows (marked with white) are parallel to each other. Elements of the net are cuboid.(Photo Marilyn Piirsalu, drawing Kadi Pajupuu)

MultiWeave material depicted in Figure 11 the rows of warps are positioned as in Figure 5, b.

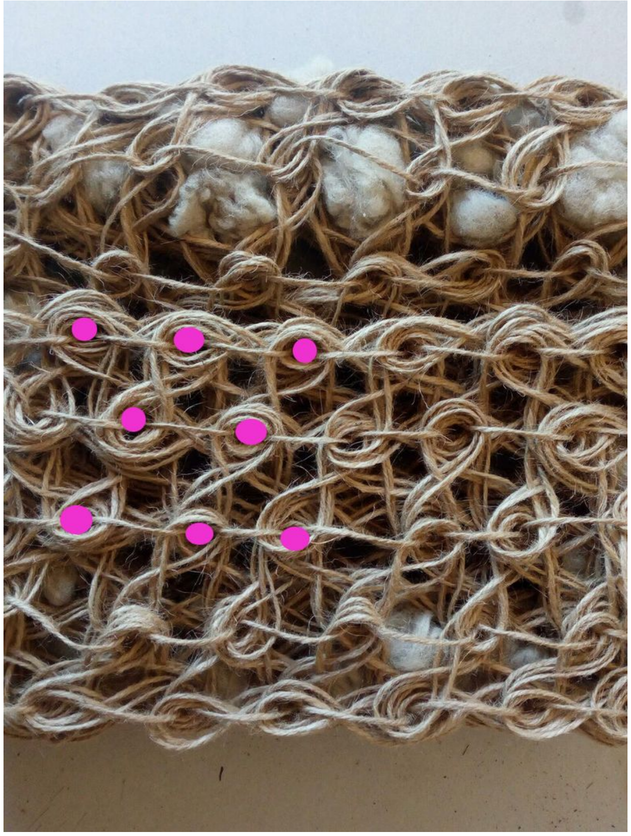

Figure 11
Kadi Pajupuu. Multiweave structure. Pink dots mark the position of warps.

Figures 12-15 show the weaving process where warp rows are placed under different angels. (as in Figure 5, d)

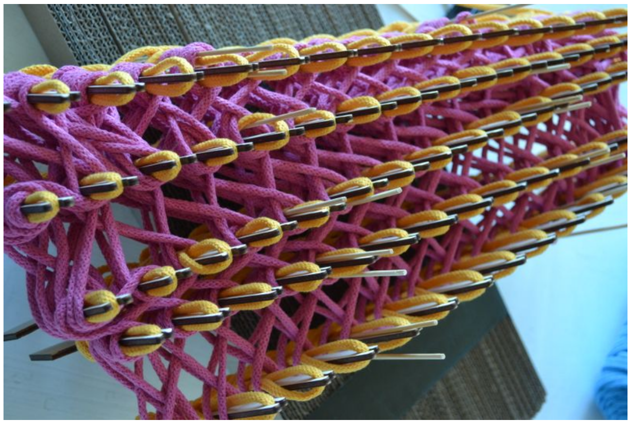

Figure 12
Weaving with yellow warp and pink weft. The rows of comb-like details that hold warp loops are placed under angles with each other.

Figure 13
Weaving with yellow weft, weft crosses the rows of warps under different angles.

Figure 14
Upper parts of warp loops are connected with each other.

Figure 15
The way how the warp loops are connected to each other affects the visual of the sample.

The appearance and properties of fabrics and structures woven with the MW technique are influenced by the position of the warps in relation to each other, the logic of the weft yarn movement, and the way the warp loops are joined together (Figure 16). Not to mention the materials used and finishing methods.

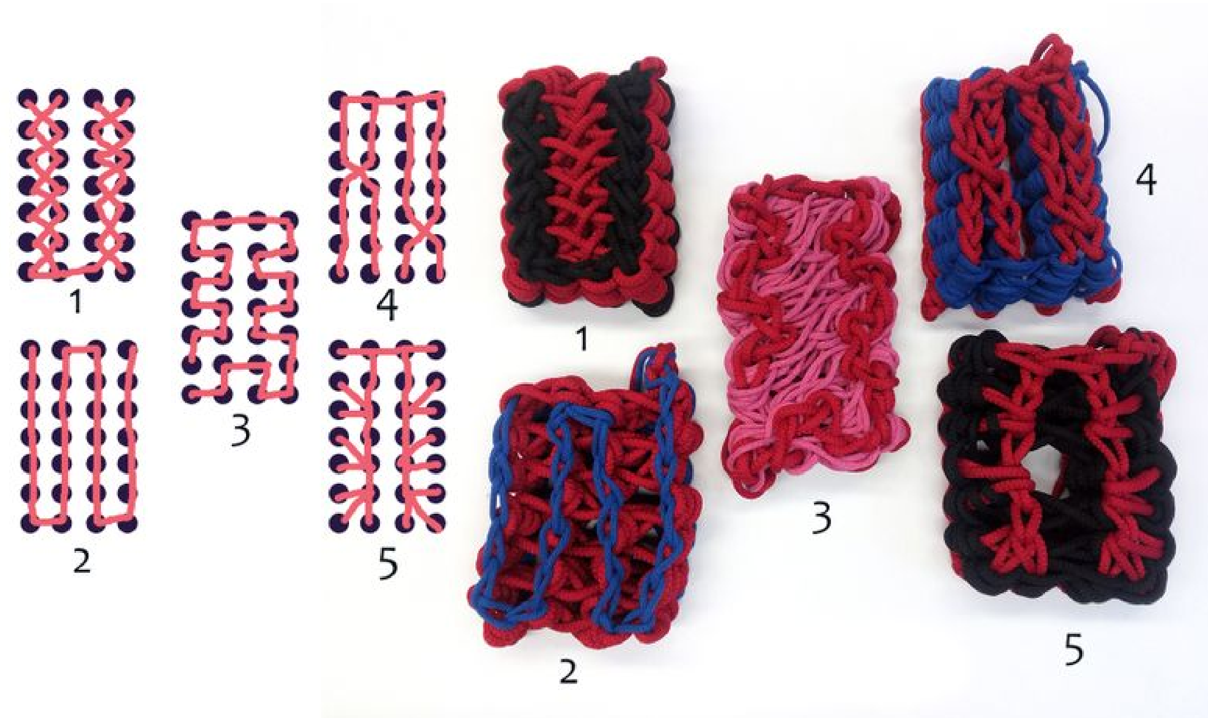

Figure 16
All 5 samples have been started with 7x4 warp rows. The paths of the wefts are different and also the way warp ends are connected with each other. Samples woven by students of Pallas UAS. (Photo and drawing by Kadi Pajupuu)

MultiWeave exhibition project GROWN

Matilda Dominique, lecturer and Maja Gunn, professor of craft at HDK-Valand were invited by Pallas UAS to work with the MultiWeave project in 2021. Together with their students at the craft programme *Textile – Body – Space* they explored the MultiWeave tool through a joint workshop where the students started to develop their individual projects and ideas of how to work with the tool.[9] In the exhibition project also students from Latvian Art Academy, Pallas UAS and invited artists participated.

The exhibition catalogue was published in 2022, documenting the different approaches to structure-building with pre-supported warp threads.[10] Authors used different materials, some searched associations in organic forms, some turned to architecture and strict logic. (Figures 17, 18, 19, 20)

Figure 17
Emilia Elfvik. Exhibition Grown, Gallery Pallas, 2022. (Photo Lisette Laanoja)

Figure 18
Emilia Elfvik. Exhibition Grown, Gallery Pallas, 2022. (Photo Kadi Pajupuu)

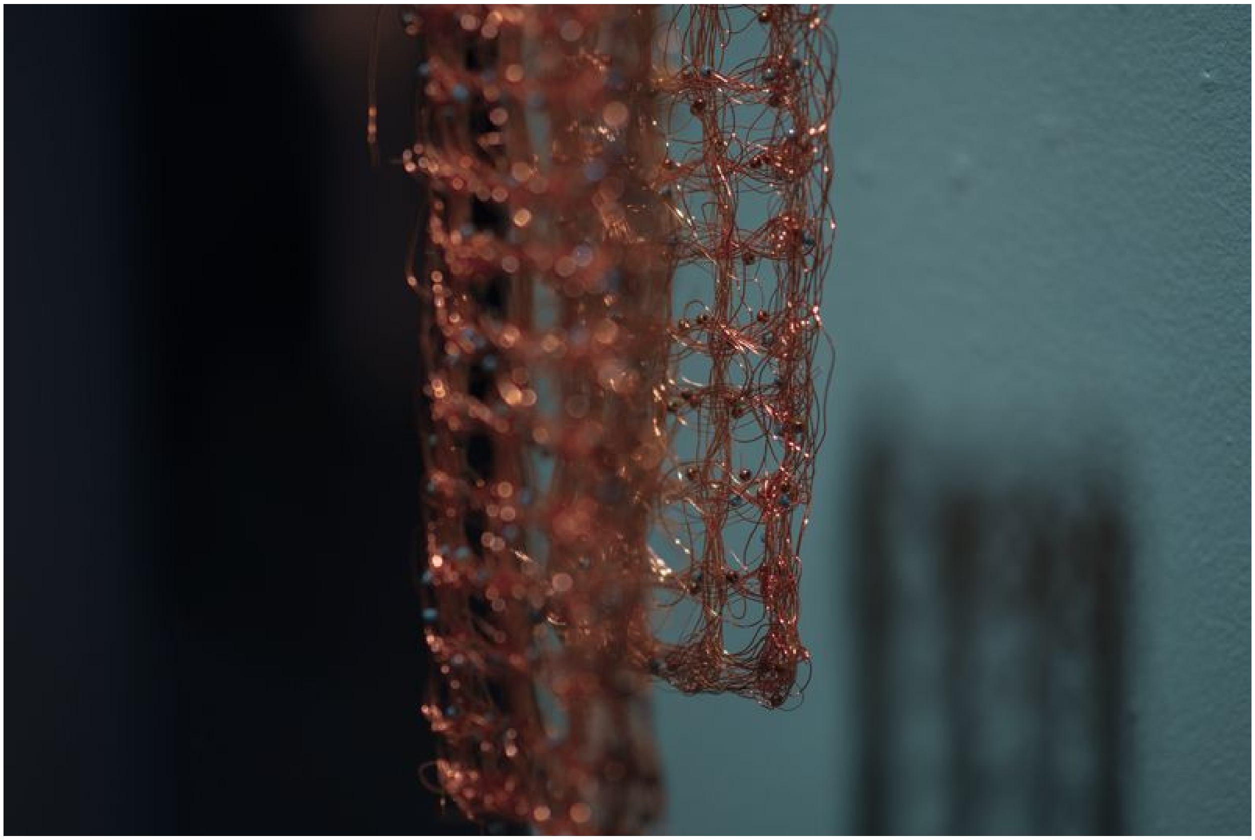

Figure 19
Una Valtere. Exhibition Grown. (Photo Lisette Laanoja)

Figure 20
Maarja Kaasik. Exhibition Grown. (Photo Lisette Laanoja)

Possible areas of use

Textile woven as a thick structured sheet can be used in interior design or even as a **geotextile**. For instance in a study project *Grows and Disappears* in Pallas UAS students wove sheets of material out of biodegradable material and waste wool and later plants were grown on them so that the roots of the plants penetrated through the structure. (Figures 21, 22)

Military use: as it is important for shielding materials to change the contours of the object to be covered, so a MW textile with **variable thickness** could be just the thing.

Figure 21
Making of MultiWeave structure from biodegradeable material with added layers of waste wool. (Pallas UAS project Grows and dissappears, photos Kadi Pajupuu)

Figure 22
MultiWeave structure was filled with soil and waste wool and tested as geotextile in a project Grows and dissapears. Pallas UAS

Fabrics with a **ribbed structure** (Figure 23), in which warp-directed ridges and an elastically springy surface are combined. Possible use as acoustic materials or wearables (Figure 24).

Figure 23
Ribbed structures created by wrapping the weft around warp threads. (Photo Kadi Pajupuu)

Figure 24
Anett Niine, Liisi Tamm. WEAWE. (Photo Lisette Laanoja)

Figure 25
Anett Niine. *Moss*. (Photo Lisette Laanoja)

Structured felt. Anett Niine has been developing a method of material formation, where the MW structure grows organically out of a woven or felted sheet of fabric[11], or another previously prepared material is pushed on the warp supports in one or more layers.[12] (Figure 25.)

MultiWeave objects can be grown in different directions, the possibility to control how the weft areas fill in the space between warps enables the play with transparency (Figure 26). With the positioning of warp threads clusters of thicker forms may be created for aesthetic or functional purposes (Figure 27).

MultiWeave is opening up new ways of creating woven materials. The method is being developed by users. Although we started with the ambition to build a machine, there is so much potential (and fun) in working manually with MultiWeave structures—develops 3d-thinking and understanding of patterns that make up structures. Hopefully, when some day we have industrial machines for MultiWeaving, then all the work talented creatives have been brought into this process, has paved the road.

Figure 26
Kadi Pajupuu. (Photo Marilyn Piirsalu)

Figure 27
Marge Allik. MultiWeave object. (Photo Kadi Pajupuu)

Footnotes

1. https://www.skeemipesa.ee/tehnohack-2016-kokkuvotte/ ↩
2. https://www.kadipuu.ee/inventions/multiweave ↩
3.

Pajupuu, Kadi. MultiWeave Applied research project at Pallas University of Applied Sciences. Overview 2017–2018. Plans for 2019

vk_2019_AppliedResearchMultiWeave4.pdf

↩

4. MultiWeave/SpiderWeave http://kriimuteh.ee/en/multiweavespiderweave-2/ ↩
5. https://www.bbc.co.uk/bitesize/guides/zp92mp3/revision/1 ↩

6. **Oluwaseyi Sosanya's 3D weaving machine.** https://youtu.be/rhRCtXcioiA?si=ltyM2JrV5jFppP-i ↩

7. *Niine, Anett. Story of Inventing. Interview with Kadi Pajupuu. MultiWeave. Viis kududa. A Way to Weave. Pallas University of Applied Sciences, 2022* ↩

8.
Samelselg, Riina. **Creating a three-dimensional architectural textile based on an ornamental structure using the MultiWeave craft technique. Master thesis. Estonian Academy of Arts. 2023**

https://tase23.artun.ee/en/graduate/riina-samelselg/ ↩

9.
Gunn, Maja, Dominique, Matilda . *A reflection on the MultiWeave tool*. Decorating Dissidence. Issue Fifteen, July 5, 2022

https://decoratingdissidence.com/2022/07/05/a-reflection-on-the-multiweave-tool/ ↩

10. *MultiWeave. Viis kududa. A Way to Weave. Compiled by Kadi Pajupuu. Pallas University of Applied Sciences, 2022* ↩

11.
Niine, Anett. Creating Felted Outerwear Fabric With Added Multiweave structure. Pallas UAS, 2022.

https://digiarhiiv.pallasart.ee/teos/2022/7482/multiweave-tehnikas-loodud-reljeefsed-viltkangad-uleroivastena ↩

12. *Niine, Anett. Story of Inventing. Interview with Kadi Pajupuu. MultiWeave. Viis kududa. A Way to Weave. Pallas University of Applied Sciences, 2022* ↩