Cutting as an Innovative Approach to Surface and Textile Design

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Abstract. We live in an age where new technologies enable materials and techniques, hitherto unconventional for this field, to start being applied in the design of surfaces and textiles. One such technique is cutting. Used for the creation of works with high artistic value, the manual cutting of paper has been developed to the level of an autonomous art form: kirigami – the Japanese art of cutting paper. Inspired by the technique of kirigami, designers and artists today continue to create two- and three-dimensional surfaces and artworks through patterns of cuts in a wide variety of materials such as textiles, polymer foils, wood, metal and others. These cuts can be made by hand, or cut by machine, using technologies such as laser cutting. Novel technologies and materials open the way for an innovative expansion of the characteristics, functions and the aesthetic value of the textiles and surfaces created through these processes. The in-depth study and calculation of the geometry of such patterns of cuts also plays an important role in the scientific research of “smart” surfaces, as well as of surfaces which have the capability to morph from a two-dimensional structure into a three-dimensional one and vice versa. The current research has as its aim to survey how contemporary designers study and develop cutting techniques in unconventional ways, such as creating three-dimensional structures using minimal manipulation, engineering the properties of surfaces and finding alternative ways of constructing objects. The relation between structure, function and aesthetics and the technologies and materials used will be analysed to determine prevalent tendencies in the field.

1. Introduction

1.1. Cutting as a form of art
Cutting has existed as a form of art for a long time. Cut images are created on the basis of the principle positive – negative, e.g. material and free space. While other techniques for the creation of pictorial images add extra material, e.g. pigment, to the base material, e.g. paper, in cutting material is removed in order to create an image.

Simplicity and accessibility make the technique of cutting a part of folk traditions of art worldwide. Some of the oldest is the Chinese. The Chinese are thought to have cut out images predating the invention of paper. One of the earliest records of the practice we find in “Records of the Grand Scribe” by Sima Qian, where he describes how a king gave a leaf from a pawlonia tree, cut into the shape of a jade token, to a prince in order to enfeoff him. [1, 2]
This story reveals not only the ancient origins of cutting, but its ritual function. The cutting out of paper images is part of many Chinese folk customs. The images themselves are rich in symbolism, which derives from ancient Chinese philosophy.

Many of the applications of the cutout paper images were decorative, for example as window decoration, or as template for embroidery or the decoration of pottery, etc. A notable example we find in the national dress of the Miao people, who had no writing. Instead, they tell the story of a battle that took place 4500 years ago by means of embroidered patterns, produced with the help of cut templates. [3]

Even before the invention of paper, different sheet materials were being cut: metal sheets, leather, silk. [4] The invention of paper by Cai Lun in 2nd century CE could be considered as the beginning of paper cutting as a form of art. [5] Nowadays the Chinese art of cutting paper is called jiǎn zhǐ (Ch. 剪纸 – “cutting paper”).

The technology of paper-making was brought to Korea from China along with Buddhism and from there also to Japan in the 6th century CE. [2, 6] One of the ritual applications of cutting was for the manufacturing of shide (Jp. 紙垂 – “paper prayers”) – objects most often made out of paper through cutting and folding and used as ritual offerings to the deities of the indigenous Japanese religion Shintō. [7] The manipulation of paper in this way creates a structure whose length exceeds the length of the original sheet, simultaneously acquiring a three-dimensional quality as well. Thus cutting goes beyond pictorality – it creates a sculptural effect, an object. During the 11th century CE, mon-kiri (Jp. 紋切り – “cutting of crests”) which is the art of making cutouts of Japanese family crests out of paper emerges in Japan. [8] What is specific about this practice is the folding and subsequent cutting out, thus fashioning an image with bilateral or radial symmetry. [9] These two cases exemplify cutting out and cutting through which enable a pattern or structure with repeating elements to be created.

This kind of cutting is nowadays better-known under the term kirigami (Jp. 切り紙 – “cutting paper”), coined by Florence Temko in 1962 in her book “Kirigami, the creative art of cutting paper”. [10] Today the term is mostly used to connote the cutting out and the cutting through of patterns made of repeating elements and the thus achieved three-dimensional effects. [11] The current article will focus on this aspect of kirigami, its mechanics and application in the sphere of textile and surface design.

1.2. The role of materials and technologies for cutting as a technique used for the design of surfaces and textiles

Initially different sheet materials were used for cutting and later the artform of paper cutting emerged with the invention of paper, which we can observe today being transferred onto other sheet materials, typical for the current age, and even at an invisible, nano-scale. [2] The development of new materials inspires new applications for cutting as a technique for the design of surfaces at any scale – from the nano to macro level.

Contemporary technologies such as laser cutting and others enable the application of cuts in sheet materials such as fabrics, polymer foil, veneer, latex and others, which would otherwise be difficult to manipulate by hand. While in cutting as a form of art the accent lies as much on the pattern being created by the cuts, as on the paper used and virtuosity of the handiwork of the artist, laser cutting is fast, easy and precise and simultaneously enables mass production, which is essential for design.

1.3. Various applications of cutting as a technique for the design of surfaces and textiles

The currently blooming technique of kirigami is a great focus of interest in the fields of design, material engineering, architecture and others, as it offers a simple, economical and effective process for the design of surfaces through structuring achieved by cutting.

In textile design, surfaces with a netted structure are created by the cutting of conventional textiles, leather and so on. Such surfaces have been used in the field of fashion by designers such as Dion Lee
[12], Giorgio Armani [13] and others. Since the beginning of her career, designer Iris van Herpen has been creating structures with the use of cutting. In 2017, in collaboration with architect Philip Beesley, she designed dresses with elastic surface, created by the cutting of a dense pattern of waves in sheets of mylar fabric. The effect achieved is a fast-moving structure with a three-dimensional effect. [14, 15]

Kirigami is a subject of scientific interest, because it enables the direct structuring of particular areas in a sheet of material. Furthermore, the specific qualities of a flat sheet of material are combined with the qualities informed by particular geometries. Research has lead to new forms of kirigami such as nano-kirigami [2] – kirigami applied at the nano-scale with the aim of informing desired photonic functions – and kiri-kirigami, literally “cutting cut paper” [16] – the result of in-depth research on the behaviour of already cut surfaces and their subsequent improvement through additional cuts or notches.

Kirigami-based structures can be “programmed” to shapeshift. Surfaces consisting of such structures could find application in architecture as “smart” windows, which can let in or block sunlight through the opening and closing of the structure [16]; as solar cells, designed to follow the sunlight through morphing their surface structure without the need for moving the entire panel, thus providing maximal energy efficiency [17]; in soft robotics, in the form of a surface that enables crawling like the scales of a snake [18]; or even as shoe soles structured in such a way as to prevent slipping [19], etc.

2. Cutting as a tool for the creation of two- and three-dimensional surfaces
The creation of three-dimensional structures using only a two-dimensional sheet material without any addition can be an artistic decision, as well a mathematical, engineering or other solution. The different varieties of kirigami enable design and production processes using minimal intervention and amount of material.

Kirigami uses cutting through, cutting out and folding.

Cutting through is the application of a pattern of cuts in a surface, without removing anything from it. Patterns of a decorative as well of a functional character can be cut. From a mathematical point of view, cutting through is similar to division. A mathematical plane (two-dimensional, without volume, consisting only of points) can be theoretically endlessly divided.

Cutting out removes parts of a surface, similar to subtraction in mathematics, thus leading to lightening.

Both cutting through and cutting out can create structures which allow for expansion of the surface. The cuts and the cut outs provide the possibility for the opening of extra space, e.g. for the increase in volume of the structure without additions to the surface area.

Folding has the reverse function – it tightens, compresses, reduces the volume of a structure, without reducing its surface area.

2.1. Using cutting out and cutting through in combination with folding
Two principal ways for the creation of three-dimensional structures out of a two-dimensional material are folding and cutting. For example, in classical mon-kiri the paper is folded, after which parts of it are cut out, resulting in an image consisting of repeating elements. [8]

Another option is for a pattern of cuts to be applied first, after which the cut sheet to be folded at preliminarily planned places with the aim of the structure acquiring a three-dimensional quality, which is a widely-applied practice in contemporary kirigami. Three-dimensional structures can be created with such techniques. For example, honeycomb-type structures are characterized by lightness and stability, whereby their construction on the basis of a flat sheet can produce functions such as shapeshifting and others. [20]

2.2. Plain cutting
Kirigami does not imply that it is obligatory to cut parts of the material out. The cut motifs can be linear, i.e straight or serrated lines or waves, applied into the material in the form of cuts. When the
thus manipulated surface “unfolds” or “opens up”, the sheet material is transformed into a three-dimensional structure or even a sculpture. [9]

3. Cutting as a tool for informing the qualities of surfaces

All the above-described options allow for the creation of structures with intentionally aimed at qualities such as stability, filigreeness, elasticity, and others, determined by the geometric proportions and the positioning of the folds as well as the cuts. Flexible and adaptive structures can be created, which unfold the advantages of the flat sheet material. Another possibility is to create surfaces which can morph from a two-dimensional into a three-dimensional state and back.

3.1. The role of the material

By applying a pattern of cuts to a flat sheet, its qualities can be altered in such a way that it acquires characteristics which are not intrinsic to it. In this way, the qualities of the material composing the surface remain unaltered, e.g. it is the structuring which changes these characteristics. For example, a piece of paper which is not perceived as elastic can become such by the application of a pattern of cuts. Furthermore, by varying the proportions of the pattern of cuts the degree of elasticity of the sheet of paper can be controlled. [21]

Elasticity is not the only quality which can be obtained by cutting a sheet of paper or another material. This type of structuring enables the flat sheet to form diverse shapes and volumes. A variation of the patterns, used to create elasticity, is also used for the fashioning of honeycomb-type structures, where cutting is combined with folding. [20] Depending on the material used it is possible for the thus formed surface to become a permanent three-dimensional form, e.g. by the use of a metal foil.

3.2. Exploring the relation between structure, material and function

The relation between structure, function and sense perception was the inspiration for my project Resonance (supervisor: Prof. Dr. Zane Berzina, Art Academy Weissensee – Berlin, 2015). The project explored the possibility for the creation of elastic structures – nets – out of inelastic polymer sheets using the cutting technique. A pattern was developed through which a sheet could be transformed into an elastic net, which could morph from a two-dimensional structure into a three-dimensional one, and vice versa. This principle is the basis for a collection of adaptive sculptural surfaces, formed out of a variety of sheet materials and manipulated only through strategically positioned laser cuts. [21]

![Figure 1. An elastic surface structure obtained using the cutting technique.](image)

A student work by Dafna Stoilkova, supervisor Prof. Dr. Zane Berzina, Art Academy Weissensee – Berlin, 2015. [21]

4. Cutting as an alternative approach for constructing objects

The capabilities of the technique of cutting – the achieving of three-dimensional structures out of two-dimensional surfaces, as well as the alteration and informing of their qualities – lead to the idea that
the structuring of surfaces can turn into the constructing of entire three-dimensional objects. The advantage of this alternative method for construction is that it offers the possibility for the fashioning of sculptural forms, using a single two-dimensional sheet of material, thus reducing the number of manufacturing steps.

4.1. Constructing zero-waste accessories through cutting

The technique of cutting allows for the creation of zero-waste products, such as a sustainably produced bag (Project CUT, supervisors: Prof. Clara Leskovar, Prof. Doreen Schulz, 2018, Art Academy Weissensee – Berlin). The bag is constructed out of a single piece of sheet material and is manufactured in one single step through laser cutting or a similar technique. [22]

![Figure 2. A net bag constructed from a single piece of sheet material using only laser cutting. A student work by Dafna Stoilkova, supervisors Prof. Clara Leskovar, Prof. Doreen Schulz, Art Academy Weissensee – Berlin, 2017.][22]

4.2. Cutting as an approach to constructing garments

A further possibility of the cutting technique is the creation of entire garments, accessories and more. Based on the experience from the projects Resonance [21] and CUT [22], an entire dress is fashioned out of a single piece of material using only cutting as a technique for surface design and construction. The dress turns from a flat cut-through sheet into a three-dimensional functional object when worn on the body.

![Figure 3. A dress, constructed and surface structured using only the technique of cutting. A work by Dafna Stoilkova, presented during the Global Qipao Invitational Exhibition 2020 at the China National Silk Museum in Hangzhou, China.][23]
5. Further aspects of the process of structuring using cutting

The technique of kirigami enriches the palette of ways for the transformation of an idea into material reality, whereby its chief distinguishing quality is that the sole thing required is a drawing which needs to be cut. In this way of structuring, the flat material can attain a two-dimensional pattern or morph into a three-dimensional structure, which informs its functional and aesthetic qualities and can effect a play on perceptions.

5.1. Relation between structure, function and aesthetics

The design process which uses cutting as a tool for the structuring of surfaces can be connected to the solution of a particular mathematical problem. The aimed functionality can be achieved through a pattern with a particular geometry. This specific geometry is by itself a two-dimensional pattern with its own aesthetic qualities. When stretched, the pattern can “come to life”, morphing from a drawing into a three-dimensional form. This ability by itself can also be perceived as an aesthetic quality.

Since the mechanism of creating a three-dimensional structure can obviously be found in a two-dimensional pattern, the reverse approach is also possible – by the cutting of an artistic drawing, its pattern can prove to have some unexpected functional features. By virtue of this alternative design process, the quest for artistic expressiveness can turn into a constructive solution. On the other hand, the development of a precisely calculated geometry can result in a structure with particular aesthetic qualities, which could sometimes also be perceived as decorative. Thus, functionality and aesthetics become synchronized by means of using a single technique in one single step – cut.

5.2. Relation between structure, material and sense perception

In the context of this article, surfaces with a three-dimensional quality are formed out of a structure which can be static or kinetic. The structure can be static when its motion is limited across the surface. The structure can become dynamic through a pattern of overlapping motifs, which either repeat or vary, forming nets or similar structures when unfolding. [21] An external activation of such a net by pulling etc., induces movement that causes the three-dimensional structure, for instance, to open or close. In this way the structure becomes “active”, kinetic, interactive with its environment. The degree of staticity or dynamicity is determined also by the material used.

While there are structures in areas such as architecture and material engineering created to react to external stimuli such as light, heat, etc., in fashion the mere movement of the human body can create an interaction. This pertains particularly to the experimental dress described above in this article. The morphing from a two-dimensional pattern into a three-dimensional structure and back, kinetically “activated” by the motion of the human body, the confusing materiality of an elastic structure constructed out of an inelastic material – all of these create a play with the senses.

One particular poetic aspect of such structures is that they literally enter a higher dimension – the two-dimensional sheet of material “unfolds” into a three-dimensional structure when kinetically activated by the body. By “doing” so the structure becomes active, alive, which can make its wearer aware of the role of the clothing as an active producer of sensory experiences and thus create an alternative relationship between the wearer, their garment and their environment.

This notion is by no means new. In the beginning of the 20th century Sonia Delaunay created the model Robe Simultanée – “the simultaneous dress”. The dress is created on the principle of the “synesthetic melting of time, movement, sound and colour”, reflecting Delaunay’s concept of oneness of the body and its environment. [24] The Delaunay’s simultaneous dress with its combination of colour, composition and material texture invokes sensations which influence the wearer’s perception of their own body, their environment and the relation between the two.
6. Conclusion

The examples reviewed in the current article have outlined some of the capabilities of the cutting technique, and especially in its kirigami variety: the creation of two- and three-dimensional structures; the altering and informing of qualities of a flat sheet of material; a design process which combines the structuring of surfaces and the construction of objects, among others. All these aspects make kirigami a technique, which will continue to be of interest in various areas of creativity, covering the broad range from the artistic to the scientific and finding conceptual and experimental, as well as practical applications.

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All images
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