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Original article

# Textile heritage motifs to decorative furniture surfaces. Transpose process and analysis

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ABSTRACT

Contemporary digital technologies offer the possibility to preserve the ancestral motifs and symbols and pass them on to the next generations. These databases can be used not only for traditional crafts and heritage conservation, but also for modern applications, including furniture, making the national/universal heritage to be worldwide known and appreciated. This paper presents a method to valorise in furniture surface decoration two symbolic traditional motifs collected from textile clothes originated from a central region of Transylvania. For this purpose a digital reproduction software, a computer-aided design and a simulation software of the Computerized Numerical Control (CNC) router milling process were used, investigating two methods of processing wood materials with two types of tools. Based on the theoretical approach, an experimental plan was set based on Taguchi full factorial design of experiment for four factors and two levels, including two digitized traditional motifs, two types of furniture raw materials (oak wood and medium density fibreboard-MDF), two tools angled at 90° and 120° and two processing methods (Engrave and V-Carve). The replicates of the traditional motifs processed by CNC router on furniture materials were afterwards visually analysed from the aesthetic point of view and then were subjected to an ImageJ analysis for objective calculation of the processed area for all variants. The analysis was combined with the processing time indicated by the simulation software for each variant. The results showed that transposing the motifs on surfaces, depends not only on the tool characterstics, but also on the material. Processing the motifs on MDF was more accurate than on wood. From all variants, engraving with the 120° tool seemed the best compromise between motif appearance and processing time.



## 1. Introduction

The historical and cultural heritage has to be preserved and handed over to the next generations. A special category of cultural heritage includes traditional textiles and costumes. As a general truth, people used symbols and signs that protected them, trying to understand their place within the universe, communicating with cosmos, concept known as "cosmovision". They used these signs to decorate objects around them and some of them can be found in almost all civilizations that keep traces of their past, because everywhere people have represented nature and the universe [1,2].

Digitalisation can nowadays be an important tool to capture the multitude of cultural expressions, including motifs found on textile heritage. Several studies refer to software programs used for digitalization of traditional motifs belonging to the textile heritage of Romanian regions. Geographic Information System (GIS) program, for example, was used to digitalize 90 traditional motifs collected from popular costumes from Bihor, Arad and Maramureş counties (in Romania), obtaining similar results to those from the use of specialized software in graphics, such as Inkscape, Adobe Illustrator or Corel Draw and a combination of Radius-Vector (RV) function methods and Principal Component Analysis (PCA) was used for the comparison [3]. Traditional motifs from the Transylvanian ethnographic area have been analysed and stylized, preserving the symbolism and colour specific characteristic of the area, with the help of the CorelDraw vector graphics program. Subsequently, a pattern was selected and transferred by a software to embroider the respective pattern on a women's jacket, a mix between old and new [4].

Other researchers [5] brought together archaeology, dress history and digital technologies to replicate a link armour using a new method, that uses parameterization, computer-aided design

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(CAD) and physically-based rigid body simulation, demonstrating the similarities between the original object dated AD 150–220 and the replica obtained.

Preservation of the cultural heritage artefacts is a challenge, due to the variety of the factors such as improper storage conditions, climate change or flooding, which lead to the deterioration or loss of world cultural heritage. An analysis of the conservation of the traditional textile collections from Romania [6] assessed the risks to which they are exposed, proving that the microclimate play a decisive role in the degradation of the textile materials, due to the development of the bacteriological micro flora on their surfaces. In this study, a traditional Romanian shirt from a private collection (named "ie") was exposed to anthropogenic and lower environmental pressure. Due to the good store conditions, the fibres were very little affected, they didn't show discolorations or degradations. Non-destructive methods of investigation and treatment have been also developed instead of chemical and physical ones, including radiation technology and nuclear techniques [7]. Not only motifs from textiles are the subject of research and preservation in the Romanian heritage, but also the natural colours used for them. A large palette of colours obtained from biological sources were identified in belts and shirts decorations from Transylvania, dating from late nineteenth to early twentieth century, and from other geographical zones such as Wallachia and Moldavia. Most of them were found to be extracted from local sources, while others were obtained from imported materials [8].

Many traditional cultural expressions including weaving, needlework, textiles, carpets, costumes are actual or potential subjects of copyright and industrial design protection [9]. Besides intellectual property, folklore should be developed according to that natural and ancestral flow, which passes from generation to generation, helping to build an important identity, but at the same time guaranteeing the possibility of adapting to the survival needs of that culture [10]. The narratives of the Romanian weavers, technical choices and transformed materials allowing a historical exploration of an old craftsmanship, reveal the changing practices and values of textiles [11]. The researcher states that Romanian museum and ethnographic culture produced a great amount of knowledge about local patterns and typologies of craftsmanship, but any technical innovation outside these categories are often overlooked. The museum curators consider the newer forms of production as kitsch and some form of contamination of authenticity and view modification as a threat to the traditional character of regional identity, but for the weavers, fabric design is a combination of technical choices, creativity and experiential proficiency [12]. According to some studies of weaving in the southern Morocco [13], the creative weavers have technical and aesthetic knowledge and also the skills of searching for ideas, but most-of-all they have to be able to transform these ideas into material forms that please and attract the buyers. Tradition can be seen as the continuous recycling of past ideas or knowledge into new ones, thus making it difficult to distinguish between old and new ideas, i.e. tradition and innovation. Some researchers [14] identified and characterized the relevant policies and practices in order to promote, develop and preserve the craft heritage, underling the role of technology and innovation to promote and preserve craft traditions, while a broader interpretation is done for the heritage, which is seen as a concept inter-related with some themes: community, nostalgia, tradition and authenticity, contouring a multidisciplinary approach with roots in folklore and anthropology [15]. The Framework Convention on the Value of Cultural Heritage for Society (Faro Convention) promotes the understanding of heritage and its relationship to community, society and nation as it is not just a link to predecessors but also a sense of the ongoing process of change [16]. United Nations Conference on Trade and Development (UNCTAD) has been promoting international policy action to assist developing countries to enhance their creative industries and hence their creative economy for trade of tangible products which are at the cross-road amongst the artisan, services and industrial sectors and constitute a new dynamic sector in the world trade [17].

The present article is a part of an extensive research focused on collecting as many traditional motifs as possible, from the textile heritage from Țara Bârsei region, actually being collected more than 100 traditional motifs from this region. Due to the fact that a part of these motifs are found on weaved, stitched or embroidered textile objects with an age of more than 100 years, their conservation is difficult to be done, one of the main reason being that the private collectors and individuals own a large part of them. It happens that many of these objects to be unique, so they can't be seen in museums or at their owners. In this case, the motifs are reconstituted from pictures taken by the owners. An unprofessional conservation of these old objects will destroy them in time and the ornamental motifs will disappear. Therefore, digitizing traditional motifs can constitute an additional method of preservation beside conventional conservation, and together they serve for perpetuation of the motifs. An actual trend is to transfer the folklore tradition and authenticity to tangible and modern products through creative domains, such as fashion, graphic design, textile industry, craftsmanship and last but not least, furniture industry. Thus, the roots in folklore tradition and authenticity are transferred to the next generations into material forms that please and attract the people. In this respect, furniture industry is a dynamic sector in which the traditional motifs found in the textile heritage can be promoted both for the upholstered furniture and wood ornaments, promoting in the same time a national identity character of design. In modern styles of furniture, techniques such as carving, engraving or inlay are rarely used. These techniques can be revived using up-to date technology and traditional motifs as source of inspiration. In the context of Industry 4.0, based on digitalization and CAD-CAM-CAE technologies, this field of study offers best opportunities to implement in the furniture design those ornaments inspired from the national heritage, and this action requires a meticulous work of collecting and digitalization of traditional motifs, use of specialized software to transfer the information to the Computerized Numerical Control (CNC) routers, choose the right tool and optimize the processing parameters according to the selected species of wood [18,19,20] or wood composites [21,22,23]. Computer-aided design (CAD) is a numerical control system. The most popular CAD tool for professional engineers includes AutoCAD, which is software for drawing. CAD is linked to computer-aided manufacturing (CAM) in the furniture manufacturing process and Computer-aided engineering (CAE) tool use specific software to simulate the manufacturing process, helping in optimizing the machining process and designs created in CAD software. CAM software translates CAD designs into instructions for machines [18].

## 2. Research aim

The aim of this research was to use two traditional motifs collected from the textile heritage specific to the SE area of Transylvania, a historical province of Romania, by promoting the traditional style from this region in the current development of furniture, contributing this way to the preservation of the national cultural identity. The article is part of a comprehensive research of the textile traditional motifs coming from a specific region from Romania (Țara Bârsei), aiming to the capitalization of these precious motifs which belong to the Romanian cultural heritage from the end of the 19th century and the beginning of the 20th century. The capitalization of these motifs is done through digitized methods, giving the possibility to transpose them in industry for wood furniture

decoration. The method presented in this article can be applied for any other motifs from Romania or other countries in the world. The ornaments taken from objects belonging to the textile patrimony were transposed in digital format, and with the use of specialized software, the simulation of the process was performed, selecting two types of tools and two processing methods. According to the information transmitted to the CNC router, the ornaments have been processed on two types of materials used for furniture manufacturing, namely oak wood and medium density fibreboard (MDF), a composite panel made of wood fibres mixed with adhesive. Finally, a visual evaluation was done in order to select the appropriate method and tool to be used for each ornament complemented by an objective evaluation of the machined area, by using an image processing software - ImageJ, which was correlated to the processing time.

## 3. Material and methods

### 3.1. Approach

Two traditional motifs of the textile heritage from Ţara Bârsei (situated in the southeastern part of Transylvania) were used, as source of inspiration, for transposing into furniture surface decoration (Fig. 1).

This purpose required study and research of the wood milling process, in order to generate a model as close as possible to the original motif. The approach was based both on a theoretical and an experimental investigation, of this research was based on using a graphic software, a CAD-CAM-CAE application and ImageJ software following the steps presented below:

1. Digital drawing the motifs in vector format, using professional vector graphics software CorelDraw, developed by Corel Corporation and AutoCAD, developed by Autodesk.
2. Simulation of woodworking, using VCarvePro 9.519 software developed by Vectric.
3. Processing two types of materials using two types of tools and two methods on Wood router CNC IQ, based on an experimental Taguchi plan obtained with XLSTAT statistical software developed by Addinsoft.
4. Aesthetic visual analysis and objective evaluation of the processed surface area by using ImageJ software, a Java-based image processing program.

### 3.2. Traditional motifs

A significant part of the cultural heritage of the city of Brasov, the most important city in Ţara Bârsei, historical and ethnographic region of Transylvania, comes from Şcheii Braşovului, a neighbourhood with an old Romanian community. As a result of the urban influence, from the middle of the 19th century, in the area of Ţara Bârsei, the representation of phytomorphic, zoomorphic motifs and symbols had developed in Şcheii Braşovului [24]. The bunch of grapes accompanied by the vine is one of the motifs that stand out amongst those that reproduce fruit [25]. It is often found on the shirts of the Juni (horsemen from Şcheii Braşovului, whose mission is to preserve and promote the traditions of this neighbourhood and of the old Brasov town), in different ceremonies (Fig.2a). It is a symbol of the woman and considered a plant that has sacred powers [26]. The vine leaf and grape bunch are a symbol of eternal life, of talent and of the promise of salvation. The vine leaf in particular is an originally non-Christian symbol that was adopted by Christianity [2].


**Fig. 1.** Map of the region Ţara Bârsei from Romania.

The repertoire of motifs sewn and woven on the shirts of the Juni from Şcheii Braşovului reflects the preference for certain symbols, apart from the vine leaf and the bunches of grapes, such as: the sun, which represents the divinity, warmth and light that gives life and generates wealth; the moon, a symbol of fertility and femininity and a measure of time; The Tree of Life, a symbol for the cyclical character of cosmic evolution, respectively death and regeneration and of the relations that are established between earth and sky; the spiral, represented in the form of wavy or zigzag lines, symbolizes the passage of time, the return to the source, the transition from appearances to reality, from form to essence [27]. Sometimes these symbols are found on the same shirt, as shown in Fig. 2b1. Through these symbols, the belonging of the population from this geographic zone to the great universal spiritual family is demonstrated. For example, the tree of life (Fig. 2 b1–b4), one of the ancient myths, which embodies the dream of "youth without old age and life without death" is found in various forms, in the art of peoples from Europe and Asia; in their legends and beliefs, this myth appears to men as a tree whose fruit and sap are the elixir of life; in the crown of the tree or at its root are birds and frightening animals that guard the priceless treasure; images of this symbol are met in the Christian and Mohammedan practices, but also in the Armenian ones in Romania [26].

Referring to the chromatics, natural colors of the yarns are frequently used: white and black for the wool, the colour of butter for linen and hemp, but also coloured yarns in red, blue and yellow obtained in boiled plants [28]. Ţara Bârsei has a multitude of ethnic groups and specific ornamentation for each community: for the Romanians there are geometric elements with phytomorphic motifs coloured in red, dark blue and red with black on white or yellow-orange strips, for the Hungarians there are monochrome fabrics in shades of red, blue or black, and for the Saxons we found monochrome embroidery with zoomorphic and floral motifs, in shades of red, purple or black on white [29]. A part of these phytomorphic, zoomorphic and anthropomorphic motifs are common to other cultures belonging to Central and Eastern Europe, Central Asia and Mexico [2,30], because humankind has always been influenced by its environment, which served as an inspiration also for cultural expression. The flower, for example, is a part of the symbolic treasure of many people, including Romania and the region Ţara Bârsei (Fig. 3). In almost any type of culture, flowers may be symbols and signs, and there is the belief that they "speak". The flower has a feminine meaning, of one's true love, affection and it is not only an attribute of aesthetics and ornamentation, but also a source of serenity, joy, relaxation [26].

From the richness of the motifs collected from the textiles in the region Ţara Bârsei, two of them were selected for the present study (Fig. 4). The first one (Fig. 4a1) represents a hand-sewn floral motif on black velvet ribbon and was collected from the Brasov Museum of Ethnography. Saxon married women from Cristian (a small village near Brasov) used to wear a bow with two such em-


**Fig. 2.** Representations of the motifs: (a) grape leaf and stem and bunch of grapes on the shirts of Juni from Şcheii Braşovului and "The tree of life" on wearing objects from private collections: (b1) Juni shirt from Şcheii Braşovului; (b2) Saxon woman blouse chest from Ţara Bârsei; (b3) Woman blouse chest from the Rupea area; (b4) ie (traditional women's blouse) from the Maramureş area (North region of the country).


**Fig. 3.** Representations of the flower motif of "ie" (traditional women's shirts) from Romania, collected from the private collection IE Vie: (a) Neamţ area, (b) Timiş area, (c) Bran area.

broidered ribbons falling on their back. The second one (Fig. 4b1) was made by sewing in crosses technique and belongs to a private collection from Şcheii Braşovului.

### 3.3. Digital drawing and the simulation of the milling process

CorelDraw software was used to draw the digital formats of the selected traditional motifs, maintaining their exact contour, scale and colors (Fig. 4 a2, a3, b2) and have been saved as vector file formats.The vector file formats CDR were converted to DXF files in AutoCAD, and then downloaded with VCarvePro 9.519 software. The next step was to choose the tools and set up their geometry, cutting parameters, feed speeds and rotation speed for the milling operation on CNC Router. The selected tools were CMT Orange Tools 915.817.11 [31] with 90° angle (Fig. 5a) and CMT Orange Tools 663.120.11 [32] with 120° angle (Fig. 5b) and the parameters are presented in Table 1. The choice of these tools was motivated by the fact that they are recommended for engraving and bas-relief with low depth, which corresponded to the processing needs for the two selected motifs. In addition, these tools have the advantage of performing with a high feed speed during processing.

The simulation software allows two types of processing methods: Engrave with a constant depth of 2 mm, which can be applied to both closed contours and open contours and V-Carve with variable depth of 1 mm to 3 mm for the surface and 2 mm for the contour. The second method can only be applied to closed con-

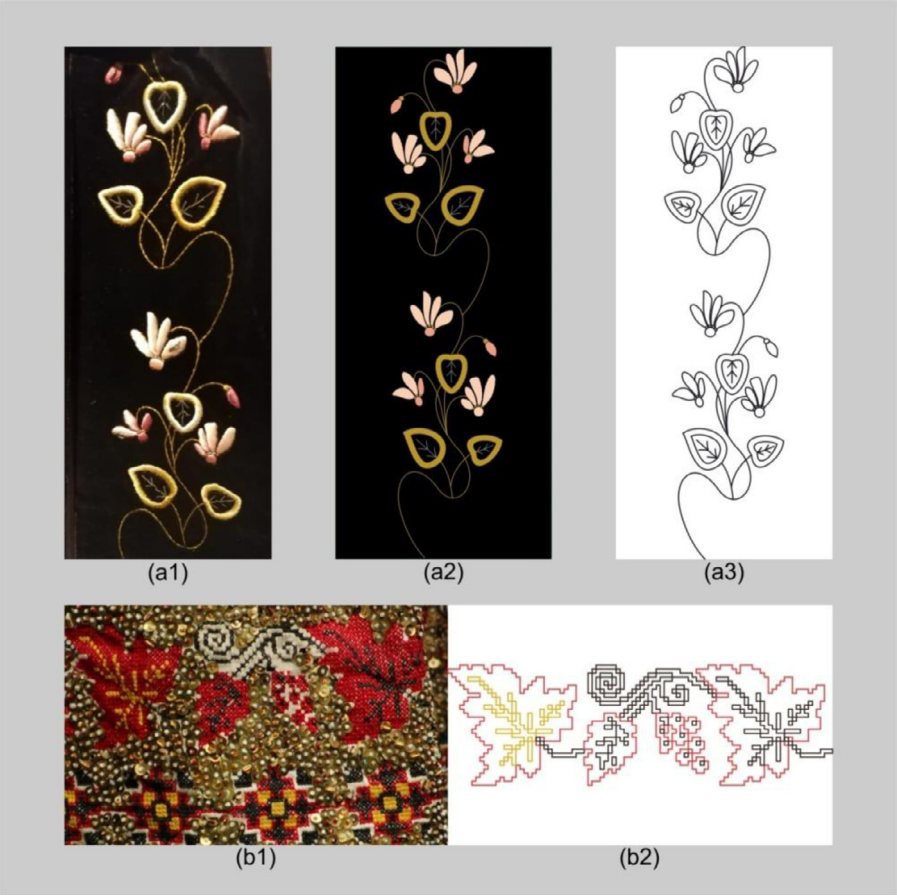


**Fig. 4.** Traditional motifs from textile objects from Ţara Bârsei subjected to the present research: (a) Model 1, Cristian; (b) Model 2, Şcheii Braşovului.

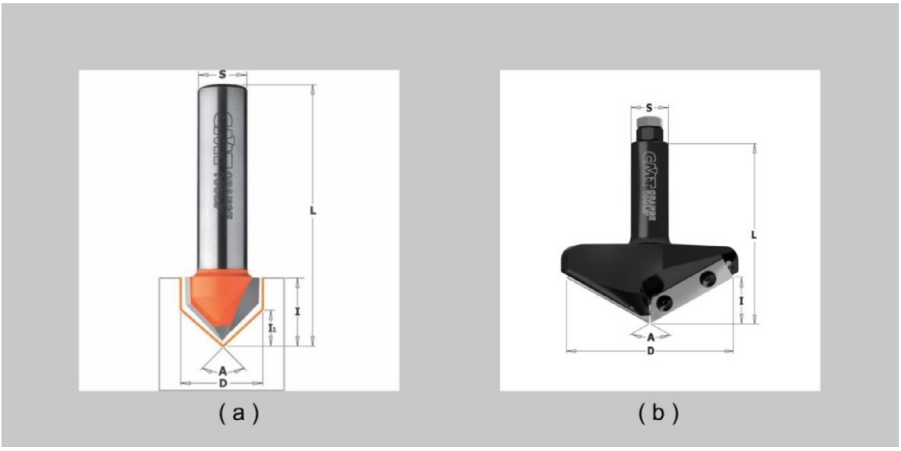


**Fig. 5.** Tools used: (a) at an angle of 90°; (b) at an angle of 120°.

tours. In the case of small lines on the contours, the two methods can be combined.

### 3.4. Processing the traditional motifs on furniture materials

The two selected traditional motifs in digital format (Fig. 4 a3 and Fig. 4 b2) were CNC routed on two materials used for furniture manufacturing, namely solid oak (Quercus robur) and MDF, using the two milling cutters presented in Figs. 5 and the two processing methods (Engrave and V-Carve) presented in Section 3.3. The experimental plan was designed with XLSTAT software based on Taguchi full factorial design of experiment for 4 factors and 2 levels. This is presented in Table 2, resulting a total of 16 experiments and 4 supplementary experiments for Model 2, issuing from the combination of the two methods (Table 3).

### 3.5. Visual and ImageJ analysis

A visual analysis of the processed ornaments was done for the aesthetic purpose, in order to chose the most appropriate form of transposition of the traditional motif taken from textile to wood. The images of the routed ornaments were afterwards analysed with ImageJ, an open source image processing program. ImageJ identifies the motifs as objects, it selects their contour and returns

**Table 1**
Milling parameters set up.

| Included angle A, in degrees | Diameter D, in mm | Spindle speed, in r.p.m. | Pass depth, in mm | Feed rate, in m/min | Plunge rate, in m/min |
|---|---|---|---|---|---|
| 90 | 32 | 12,000 | 2 | 3 | 0.9 |
| 120 | 87 | 12,000 | 2 | 3 | 0.9 |

**Table 2**
Variables used for the experimental design.

| Factors | Levels | Level 1 | Level 2 |
|---|---|---|---|
| Model | 2 | 1 | 2 |
| Tool | 2 | 90 | 120 |
| Material | 2 | Oak | MDF |
| Method | 2 | Engrave | V-Carve |

a masque image where only the objects of interest are kept. Before any measuring, the images were calibrated and a scale was set based on a known unit of length. Next step was to convert the colour image into a grey scale. To ease the identification of the features in an image the contrast was enhanced. A threshold, which is user's decision, was applied meant to retain in the image only the features of interest (the decorated motifs), while any other type of feature was removed (for example, visible large wood fibres from the MDF surface or other outliers). Together with the masque image, the software provides numerical data in a speadsheet about the measured objects such as: area and perimeter of each object, total and average area of objects, percentage and number of objects detected in an image. For this study, the software has calculated the processed area (in $mm^2$) and the percentage of the processed motifs from the total surface area. The analysis was performed for all twenty variants, taking into consideration also the routing time.

## 4. Results and discussion

### *4.1. Simulation of the milling process*

The simulation of CNC router process was performed by VCarvePro 9.519 software.The simulation process resulted in good images of the ornaments through engraving (Engrave) and carving (V-Carve) methods, highlighting the differences between the appearance of the ornaments in the two cases. The simulation of the first model with Engrave and V-Carve processing methods and with the two types of V tools angled at 90° and 120°, respectively had as result the images in Fig. 6.

The simulation results have shown small differences between the details of the first ornament (Model 1) when using Engrave and V-Carve processing methods. The circled details in Fig. 6 show this differences on the flower of the ornament, but not on the leaves. The ornament engraved with 90° looks cleaner and finer than the others. When using Engrave method, the results have shown just differences between the widths of the processing areas, wider for the case of V tool with the peak angle of 120° For V-Carve methods, no visible differences were noticed for the simulation results with the two different tools.

For the bunch of grapes and leaves (Model 2), the results of simulations are presented in Fig. 7. The Engrave method highlights the contour of the ornament and not visible differences are noticed for the simulations with the two different tools (Fig. 7a and b). In case of V-Carving, the ornament looks nicer and closer to the original motif. Carving the interior of the leaves creates a good appearance of the leaf vein and again no differences were noticed for the two different tools (Fig. 7c and d). The discontinuity of the line in the central part of the ornament in Fig. 7c,d brought suspicions about the visibility of this part on the real sample, so a combination of the two methods have been applied in simulation as a next step. Combination of Engrave and V-Carve (Fig. 7e and f) makes the ornament to look overcrowd, especially for the case of using 120° angled tool (Fig. 7f). For this model there are noticeable differences of the appearance between the three variants of the process simulation.

The two selected traditional motifs are different when refering to the technique used to decorate the textile clothes. The first model was obtained by embroiding and the second one was sewn in crosses technique and this explained the continuity of the line in the first case and the discontinuity of the line in the central part of the ornament in the second case. At a first glance, the simulation offer a good idea about how the motif on the processed surface would look like with each method applied, but a unique recommendation for a specific method to be applied in processing

**Table 3**
Taguchi experimental design and supplementary experiments.

| Observations | Model | Tool | Material | Method | Combinations |
|---|---|---|---|---|---|
| Obs1 | 1 | 90 | Oak | Engrave | Full |
| Obs2 | 1 | 90 | Oak | V-Carve | fac- |
| Obs3 | 1 | 90 | MDF | Engrave | to- |
| Obs4 | 1 | 90 | MDF | V-Carve | rial |
| Obs5 | 1 | 120 | Oak | Engrave | design |
| Obs6 | 1 | 120 | Oak | V-Carve | |
| Obs7 | 1 | 120 | MDF | Engrave | |
| Obs8 | 1 | 120 | MDF | V-Carve | |
| Obs9 | 2 | 90 | Oak | Engrave | |
| Obs10 | 2 | 90 | Oak | V-Carve | |
| Obs11 | 2 | 90 | MDF | Engrave | |
| Obs12 | 2 | 90 | MDF | V-Carve | |
| Obs13 | 2 | 120 | Oak | Engrave | |
| Obs14 | 2 | 120 | Oak | V-Carve | |
| Obs15 | 2 | 120 | MDF | Engrave | |
| Obs16 | 2 | 120 | MDF | V-Carve | |
| Obs17 | 2 | 90 | Oak | V-Carve and Engrave | Supplementary |
| Obs18 | 2 | 90 | MDF | V-Carve and Engrave | experiments |
| Obs19 | 2 | 120 | Oak | V-Carve and Engrave | |
| Obs20 | 2 | 120 | MDF | V-Carve and Engrave | |

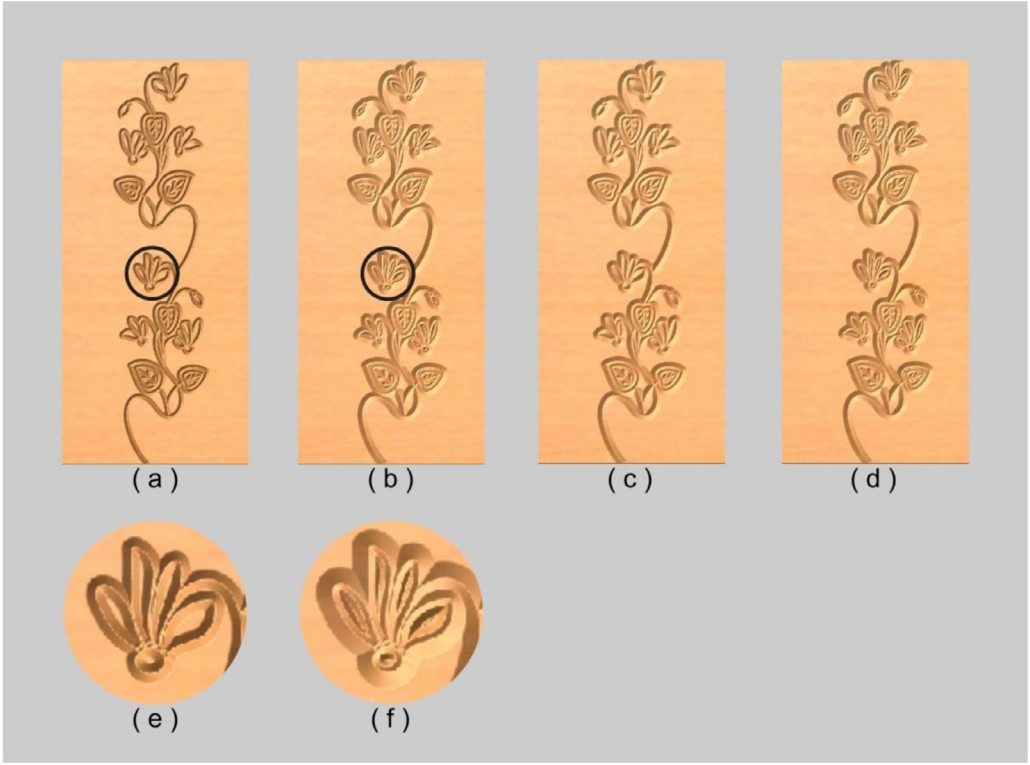


**Fig. 6.** Simulation results for Model 1: (a) Engrave 90°; (b) V-Carve 90°; (c) Engrave 120°; (d) V-Carve 120°; (e) Detail for Engrave 90°; (f) Detail for V-Carve 90°.

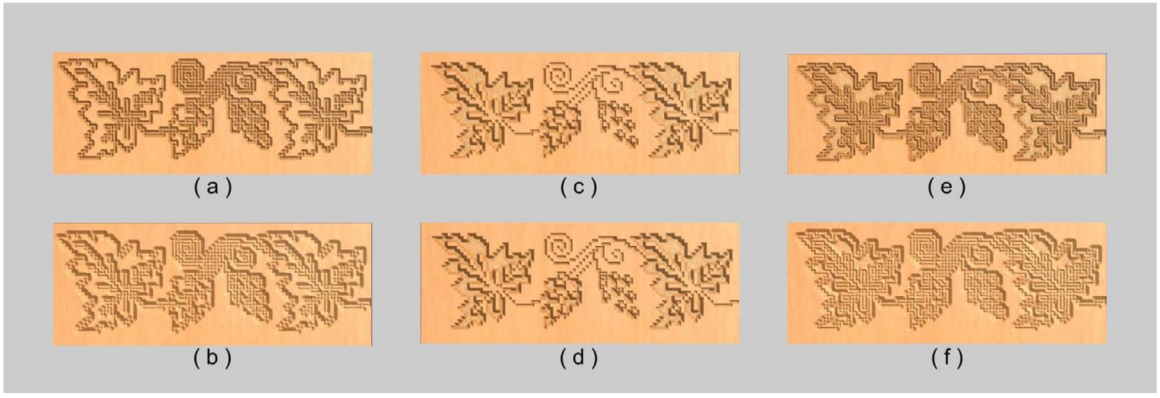


**Fig. 7.** Simulation results for Model 2: (a) Engrave 90°; (b) Engrave 120°; (c) V-Carve 90°; (d) V-Carve 120°; (e) V-Carve and Engrave 90°; (f) V-Carve and Engrave 120°.

such two different motifs is not to be done in this phase. Practical work and an aesthetic analysis of the ornaments processed on furniture materials were the further steps in evaluating the proper method to be used for each type of ornament.

### *4.2. Visual and ImageJ analysis*

The objective of the visual analysis was to select the method, tool and material that offer the best option for the traditional motifs to be transposed on the furniture, as ornament. For both traditional motifs, MDF was the material that behaved better than oak wood, no matter of tool, or processing method. Compared to MDF case, the ornaments routed on oak wood presented burns, tearing wood grains and wood split, especially for V-Carve and combined method applied for the vine leaf.

The opinion on the aesthetic of ornaments was different on the real case compared to simulation results. Whilst Model 1 engraved with 90° (Engrave 90°) looks cleaner and finer than the others in the simulated variant, on the MDF surface the ornament was more visible and clear in case of applying Engrave 120° (Fig. 8b–left) and V-Carve 120° (Fig. 8d–left) methods.

For the second model, the ornament looked nicer and closer to the sewn motif when simulated with V-Carve method for both tools. However, the real model routed on the surface looked better for Engraving with 120° angled tool (Fig. 9b–up) as well as when Engraving was combined with V-carve for 90° angled tool (Fig. 9e–up). The suspicions raised in the simulation phase in the central part of the ornament (the circled part) for V-Carve method were confirmed for the routed motifs, this part being less visible on the ornament.

The material removed from the surface and the processing time are important issues when processing wood materials, because they are connected to the tool wear and productivity. An ImageJ analysis was performed on the ornaments routered on MDF as a next step for objective calculation of the processed area for all variants. The analysis was combined with the processing time indicated by the simulation software for each variant. The images processed by the software are presented in Figs. 8 and 9 as grey

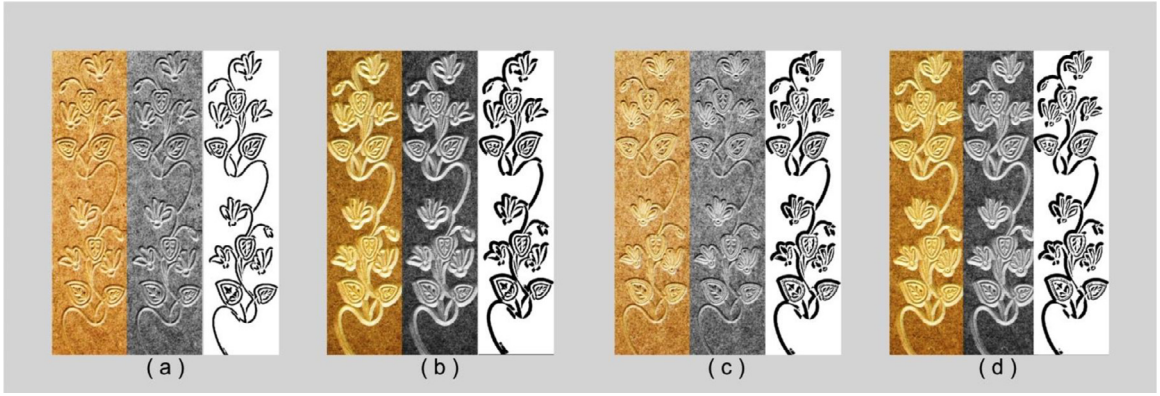


**Fig. 8.** Image analysis for Model 1: (a) Engrave 90°; (b) Engrave 120°; (c) V-Carve 90°; (d) V-Carve 120° Left image represents the motif processed on MDF material, the middle image represents the converted image into a grey scale and the right image represents the returned masque, providing numerical data about the measured objects.

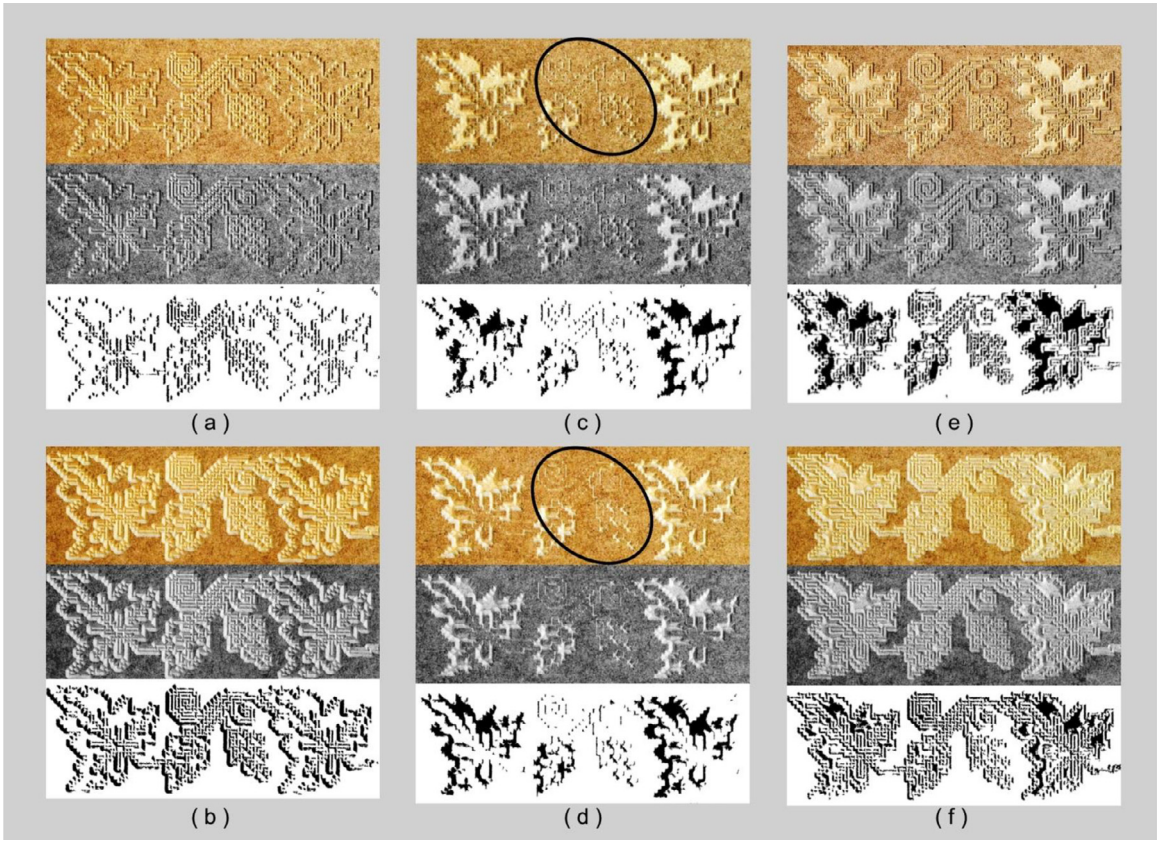


**Fig. 9.** Imagies analyse for Modelul 2: (a) Engrave 90°; (b) Engrave 120°;
(c) V-Carve 90°; (d) V-Carve 120°; (e) V-Carve and Engrave 90°; (f) V-Carve and Engrave 120° Top image represents the motif processed on MDF material, the middle image represents the converted image into a grey scale and the bottom image represents the returned masque, providing numerical data about the measured objects.

variants (middle position), whilst the motifs masks are positioned on the right side of each variant from Figs. 8 and at the bottom for the variants in Fig. 9.

ImageJ software calculates automatically the processed area of the ornament based on returned masque image, in $mm^2$ and as percentage of the total area of the wooden based panel used as support. The area and the percentage of the processed area against the total area calculated by ImageJ software for each variant are presented in Table 4. Processing times presented in Table 4 were automatically recorded by the simulation software (VCarvePro 9.519). The correlation between the processed area and the processing time for each model and variant from the experimental plan is shown by the diagram in Fig. 10.

As resulted from the diagram in Fig. 10, the Engrave method was faster than all the other methods, whatever the tool used. Engraving with 120° angled tool, in general, removed more surface material in comparison with the other processing methods and needed shorter processing times than V-Carve method.

From the results above, combining outputs of the aesthetic analysis of the ornament on the real sample, the magnitude and percentage of the proccesed areas issued by ImageJ, and the processing time obtained from the simulation phase, a conclusion on the selection of method, tool and material can be drawn. This is that each ornament needs an individual analysis for determining the most appropriate type of process, material and tool. MDF showed the best surface quality and accurate reproduction of both

**Table 4**
Images analysis results.

| Type of operation | Sample size,in mm | Processed area,in mm$^2$ | Percentage of the processed area,% | Processing time,in min:s |
|---|---|---|---|---|
| Model 1 V-Carve 90° | 370.19×92 | 6904.13 | 20.27 | 06:21 |
| Model 1 Engrave 90° | 370.19×92 | 5276.13 | 15.49 | 04:05 |
| Model 1 V-Carve 120° | 370.19×92 | 6843.38 | 20.09 | 06:05 |
| Model 1 Engrave 120° | 370.19×92 | 7528.40 | 22.11 | 03:38 |
| Model 2 V-Carve and Engrave 90° | 370.2×133 | 10,794.15 | 21.92 | 15:28 |
| Model 2 V-Carve 90° | 372.57×139.78 | 6172.43 | 11.85 | 14:24 |
| Model 2 Engrave 90° | 372.57×139.78 | 5292.38 | 10.16 | 04:20 |
| Model 2 V-Carve and Engrave 120° | 370.2×133 | 10,929.49 | 22.20 | 13:16 |
| Model 2 V-Carve 120° | 370.20×133.08 | 6871.98 | 13.92 | 12:39 |
| Model 2 Engrave 120° | 370.2×133 | 10,303.90 | 20.92 | 03:35 |

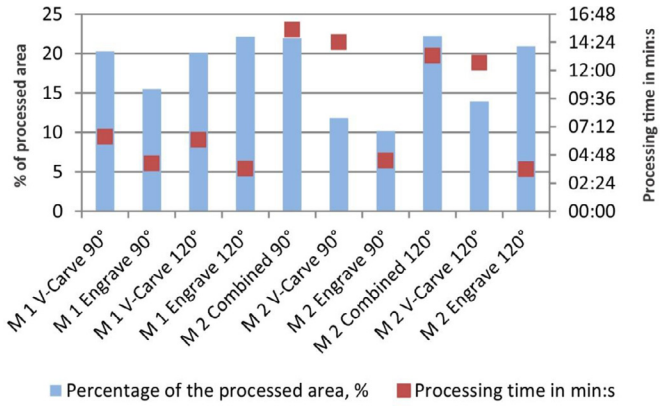


**Fig. 10.** Correlation between processed area and processing time (M 1 is Model 1 and M 2 is Model 2).

type of motifs, in comparison with wood. The differences noticed between the simulated motifs and the real motifs processed on the surface, can indicate that the processing quality and motif appearance depend not only on the tool characteristics, but also on the material, and probably its density and structure.

Engraving method with 120° tool for both models, due to shortest processing times and pleasing aestetics, could be the most appropiate choice for transposing both motifs on furniture surfaces.

## 5. Conclusions

The cultural heritage in Romania offers a richness of traditional motifs which deserve to be promoted not only as a link to tradition and authenticity, but as a source of inspiration for the creative industry and supported by digital technologies and CAD-CAM-CAE methods. In this respect, this paper is a first attempt in offering a solution of valorizing the traditional motifs collected from the textile clothes by transposing them to decorative furniture surfaces in the industrial sector, using the computerized technology. The actual advanced programmes offer the solutions to draw, simulate the manufacturing process in wood, and visual analysing the appearance of the ornament after processing, easing the selection of method and tool to be used for a better transposing of original ornament on wood surface. Through this combined computerized methods applied to decorate furniture, the people may interact with their heritage.

Two of the over 100 traditional motifs collected from the textiles in Țara Bârsei and having a symbol value, were digitized in vector format, using professional vector graphics software CorelDraw, then were imported in AutoCAD and from here, were sent to a CNC router. The two digitized traditional motifs were processed on two types of furniture raw materials (oak wood and medium density fibreboard-MDF) with two tools angled at 90° and 120° and two processing methods (Engrave and V-Carve). The result was visually compared from the aesthetic point of view and then analysed with ImageJ, calculating the total processed area and its percentage.

It could be concluded that although simulation can offer a good idea about how the motif on the processed surface would look like, the practical work has shown that the processing quality and motif appearance depend not only on the tool characteristics, but also on the material, and probably its density and structure. Each ornament needs an individual analysis following the protocol presented in this study, in order to gain a recommendation for the right process, material and tool.

MDF is more homogeneous than wood and it behaved very well for transposing the motifs to its surface. As a compromise between all variants, engraving with 120° tool, removed more surface material in comparison with the other processing methods, showed a good motif appearance and most rapid processing times. This renders it as a good choice for producing decorative surfaces for furniture, which is carrying to the next modern generation some of the universal or local heritage symbols.

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## References

[1] A. Scripcariu, S. Petac, A. Iuga, Patrimoniul UNESCO Din România pe Înțelesul Tuturor, 1, Ediția I, Piscu, Şcoala Agatonia, 2019 (Capitolele 1, 2).
[2] A. Lungu, M. Puskás, C. Coşereanu, Converges between the traditional motifs of the Romanian and Mexican textile heritage, Redefin. Comm. Intercult. Context 9 (1) (2020) 41–46. http://www.afahc.ro/ro/rcic/2020/rcic\prime;20/volum_2020/041-046%20Lungu%20et%20al.pdf
[3] L. Indrie, Z. Zlatev, D.C. Ilieş, A. Sturza, M. Dochia, M. Gozner, G. Herman, T. Caciora, in: Implementation of Image Processing Techniques As a Tool For Form Analysis of Romanian folk Elements, 71, Industria Textila, 2020, pp. 492–498, doi:10.35530/IT.071.05.1690.
[4] L. Doble, O. Stan, M.D. Suteu, A. Albu, G. Bohm, A. Tsatsarou-Michalaki, E. Gialinou, Romanian traditional motif - element of modernity in clothing, IOP Conf. Series: Materials Science and Engineering în:, 254, 2017, doi:10.1088/1757-899X/254/17/172009.
[5] M.A. Wijnhoven, A. Moskvin, Digital replication and reconstruction of mail armour, J. Cult. Herit. 45 (2020) 221–233, doi:10.1016/j.culher.2020.04.010.
[6] D.C. Ilieş, G.V. Herman, T. Caciora, A. Ilieş, L. Indrie, J. Wendt, A. Axinte, M. Diombera, C. Lite, Z. Berdenov, A. Albu, Considerations regarding the research for the conservation of heritage textiles in Romania, IntechOpen, Waste in Textile and Leather Sectors, 2020, doi:10.5772/intechopen.91393.

[7] International Atomic Energy AgencyUses of Ionizing Radiation For Tangible Cultural Heritage Conservation, International Atomic Energy Agency, Vienna, 2017 (Chapter Foreword).
[8] I. Petroviciu, I. Teodorescu, F. Albu, M. Virgolici, E. Nagoda, A. Medvedovici, Dyes and biological sources in nineteenth to twentieth century ethnographic textiles from Transylvania, Romania, Herit. Sci. (7) (2019) 15, doi:10.1186/s40494-019-0255-0.
[9] Word International Property OrganizationConsolidated Analysis of the Legal Protection of Traditional Cultural Expressions/Expressions of Folklore, 2003 Background Paper no. 1Chapter VII.
[10] B. Pozzo, Fashion between inspiration and appropriation, Laws 9 (5) (2020) 1–27, doi:10.3390/laws9010005.
[11] M. Buchcyzk, To weave or not to weave: vernacular textiles and historical change in Romania, Textile 12 (3) (2015) 328–345, doi:10.2752/175183514X14156359536980.
[12] M. Buchcyzk, Beyond the Horniman Museum: history, Heritage and Craftsmanship in the Collection of Romanian artefacts. Doctoral thesis, Goldsmiths, University of London, 2015 Chapter 6, doi:10.25602/GOLD.00012305.
[13] M.N. Naji, Weaving and the Value of carpets: Female Invisible Labour and Male Marketing in Southern Morocco, Doctoral thesis, University of London, 2008 Chapter 10 https://discovery.ucl.ac.uk/id/eprint/1444467 .
[14] Y. Yongzhong, S. Mohsin, S. Xiaoting, Y. Ruo, Preservation of cultural heritage embodied in traditional crafts in the developing countries. a case study of pakistani handicraft industry, Sustainability 10 (5) (2018) 1336, doi:10.3390/su10051336.
[15] C.E. Clopot, Russian Old Believers' Heritage and Traditions in Romania – Bridging the Past and the Future, Doctoral thesis, Heriot Watt University, 2017 Chapter 2 http://hdl.handle.net/10399/3346 .
[16] G. Fairclough, in: The Cultural Context of Sustainability–Heritage and living, in Heritage and Beyond, Council of Europe Publishing, Strasbourg, 2009, pp. 125–127.
[17] United Nations 2008, Creativ economy report 2008 (Capitolul 1), https://unctad.org/system/files/official-document/ditc20082cer_en.pdf.
[18] I. Paiu, A. Androne, C. Coşereanu, CAD-CAM-CAE in wood industry, A case study for perforate ornaments processed on CNC router, Proligno 16 (3) (2020) 60–67 http://www.proligno.ro/en/articles/2020/3/PAIU_Final.pdf.
[19] E. Hazır, K. HüseyinKoc, Optimization of wood surface machining parameters in CNC routers: response surface methodology (RSM) approach, Int. J. Sci. Res. Eng. Technol. 5 (10) (2016) 494–501 https://www.researchgate.net/publication/309670014_Optimization_of_wood_surface_machining_parameters_in_CNC_routersResponse_surface_methodology_RSM_approach.
[20] D. Kazlauskas, V. Jankauskas, R. Bendikienė, G. Keturakis, L. Mačėnaitė, in: Wear of Cemented Tungsten Carbide (WC) Router Cutters During Oak Wood Milling, 23, Mechanics, 2017, pp. 469–472, doi:10.5755/j01.mech.23.3.18482.
[21] U.K. Işleyen, M. Karamanoglu M, The influence of machining parameters on surface roughness of MDF in milling operation, Bioresources 14 (2) (2019) 3266–3277 https://www.researchgate.net/publication/346964613_The_influence_of_machining_parameters_on_surface_roughness_of_MDF_in_milling_operation.
[22] R. Kminiak, A. Banski, in: Variability of Surface Quality of MDF Boards At Nesting Milling On CNC Machining Centers, 59, Acta Facultatis Xylologiae Zvolen, 2017, pp. 121–130, doi:10.17423/afx.2017.59.1.12.
[23] K. Laszewicz, J. Górski, J. Wilkowski, P. Czarniak, in: Analysis of Dimensional Accuracy of MDF Milling Process, 58, Wood Research, 2013, pp. 451–464. https://www.researchgate.net/publication/287103430_Analysis_of_dimensional_accuracy_of_MDF_milling_process.
[24] N. Dunăre, et al., Broderii şi împletituri româneşti, in: E. Antoni, P. Binder, P. Boca, R. Capesius, M. Dunăre, N. Dunăre, et al. (Eds.), Ţara Bârsei, Volumul II, Editura Academiei Republicii Socialiste România, Bucureşti, 1974, pp. 349–354.
[25] N. Dunăre, Ornamentică Tradiţională Comparată, Editura Meridiane, Bucureşti, 1979 Chapter Semantică ornamentală.
[26] R. Antonescu, in: Dicţionar De Simboluri şi Credinţe Tradiţionale Româneşti, Ediţie digitală, 2016, pp. 256–257. http://cimec.ro/Etnografie/Antonescu-dictionar/Dictionar-de-Simboluri-Credinte-Traditionale-Romanesti.html. 543, 709.
[27] A. Lungu, M. Puskás, in: Patrimoniul Textil Din Şcheii Braşovului. Câteva consideraţii Asupra Simbolurilor şi motivelor Tradiţionale Cusute Pe Cămăşile Junilor Albiori şi Roşiori Din Şchei, în A. Stănescu, Portul de Sărbătoare Al Junilor din Şcheii Braşovului: Portul Roşiorilor şi Al Albiorilor, Monitorul Oficial, Bucureşti, 2017, pp. 60–64.
[28] A. Scripcariu, Patrimoniul Cultural, Judeţul Braşov, Ediţia II, Şcoala Agatonia, Piscu, 2015 Capitolul 9.
[29] Enciclopedia Românie. Etnografia Ţării Bârsei Retrived from: http://enciclopediaromaniei.ro/wiki/Etnografia_%C5%A2%C4%83rii_B%C3%A2rsei (09.01.21).
[30] S. Busatta, The Tree of life design from central Asia to Navajoland and back (With a Mexican Detour) Part 1, Antrocom. Online J. Anthropol. 9 (1) (2013) 205–220 http://www.antrocom.net/upload/sub/antrocom/090113/20-Antrocom.pdf.
[31] CMT Orange Tools, V-Grooving Router Bits (90°), Retrived from: https://www.cmtorangetools.com/eu-en/industrial-router-bits/v-grooving-router-bits-90deg (15.01.21).
[32] CMT Orange Tools, V-Groove–folding–sigmaking CNC router cutter, Retrived from: https://www.cmtorangetools.com/eu-en/router-cutters-chucks-for-cnc/v-groove-folding-signmaking-cnc-router-cutter_2 (15.01.21).