Computer-aided methods for furniture decoration with traditional motifs of textile heritage

Computer-aided methods for furniture decoration with traditional motifs of textile heritage

A Lungu, L Gurău, S Georgescu and C Coşereanu

Faculty of Furniture Design and Wood Engineering, "Transilvania" University of Brasov, B-dul Eroilor, nr. 29, 500036, Brasov, Romania

cboieriu@unitbv.ro

Abstract. The present paper introduces computer-aided methods for the transposition of ornaments inspired from the textile heritage into the surface furniture decoration. Using digital technology, the furniture industry may bring into modern life the traditional motifs, contributing thus to the preservation of the cultural heritage from the region Țara Bârsei, located in Transylvania. Two motifs inspired by the traditional costumes from South-Eastern Transylvania were digitized using CorelDraw software. They were imported in AutoCAD and the information was transferred both to CNC router and laser equipment. The CNC routing of ornaments was simulated with two types of tools and two processing methods (engraving and carving) using CAD-CAM-CAE software and the models were afterward processed on wood panels by CNC router and laser equipment and then visually analysed, concluding which method and tool is suitable for each type of ornament, so to transpose better the original motif on furniture wood surface.

1. Introduction

A specific concern of each generation is to perpetuate the cultural heritage to the future, bringing it in the modern life through digital technologies. One way to save traditional ornaments is to introduce them in various industries such as textiles, embroidery on clothing and footwear, interior design, furniture design, digital printing or graphics and design of modern products. There are several methods applied for the decoration of the furniture surfaces, such as carving, painting, marquetry or wood pyrography or engraving, but among these there are two methods that offer the advantage of advanced technology and they are laser jet engraving of wood and CNC routing of wood.

Aesthetic evaluation of laser engraving work was carried out on radial and tangential veneer cut from beech (*Fagus sylvatica*), pine (*Pinus sylvestris*), chestnut (*Aesculus hippocastanum*), mahogany (*Swietenia macrophylla*) and *Sapelli* wood, and the best aesthetic perception was achieved on light coloured wood species, because of the contrast between the pattern and background [1]. Different image conversion methods and colour image reproduction in burned wood surface were used to analyze the colour shades obtained through pyrography with various intensities of laser beam [2]. Apart from studies of aesthetics and colour reproduction, investigation on cutting width, processed surface quality, heat affected zone and wood surface burning were also conducted by researchers [3], and a mathematical relation between wood surface roughness and laser parameters have been determined [4]. Laser beam focal length, cutting speed and power are the important parameters to be

considered not only for laser engraving, but also for laser cutting of wood and wooden based materials, such as plywood [5].

Various species of wood were subjected to tests regarding CNC routing process and determination of optimum parameters to be used for an adequate quality of the processed areas. The quality of the routed surfaces in spruce wood (*Picea abies*), poplar wood (*Populus alba*), plywood and medium-density fibreboard (MDF) was visually analysed after scanning them with high resolution, and VCarvePro 9.519 software developed by Vectric was used to design the tool path, select the tools and parameters and simulate the routing process, transferring the information to CNC Router [6]. Other researchers have tested the CNC milling process on European black pine (*Pinus nigra* Arnold) [7], alder wood (*Alnus Glutinosa*) [8], oak wood (*Quercus Robur*) [9], evaluating the processed surface roughness for various parameters, such as depth of cutting, feeding rate, milling pattern and milling direction. A study conducted on MDF [10] concluded that to ensure an adequate reaction to the progression of tool wear during any MDF milling process, a workpiece rather than a tool should be measured. Edge-glued panels (EGP) have been also investigated for CNC router process, using five parameters: cutting direction, cutting depth, cutting width, feed rate and spindle rotation feed [11].

2. Material, methods and equipment

2.1. Traditional motifs

Historical and ethnographic region located in the SE part of Transylvania, namely Ţara Bârsei is a multiethnical one, and for this reason it is known to have a rich textile heritage. In Braşov, the main town of this region, there is a men community (named "Juni"), organized in an old part of the town named Şchei. These men preserves and still wears the popular costumes during the traditional events that take place anually. The main piece of their traditional costumes is a shirt made of white canvas with decorative stitches, decorated mainly with phytomorphic und cosmomorphic motifs, including the urn of flowers, a stylised version of the universal "tree of life" motif. A part of this shirt decorated with urn of flowers is presented in Figure 1(a). A peculiarity of the Saxon woman costume from Ţara Bârsei is the black patch tied under the chin with velvet ribbons, embroidered with gold thread and decorated with floral motifs, as shown in Figure 1(b). The sewing techniques used for the two motifs are totally different, the first one is sewing in crosses on one side (a) and the second one is full embroidery (b). These two motifs were collected from pictures taken from objects belonging to private collections, where they are very well conserved.

Figure 1. Traditional motifs from textile objects: (a) – Model 1, from Şcheii Braşovului; (b) – Model 2, from Saxon woman costume.

2.2. Approach methods and equipment

The scientific research presented in the paper includes the vector graphic design of the motifs using professional graphics software CorelDraw, followed by export of the file to AutoCAD software and import it afterwards in VCarvePro 9.519 software, developed by Vectric, for the simulation of CNC routing on wood surface, selecting the tools and processing methods.

The simulation process indicated the appropriate tool and processing method to be applied, in order to obtain the closest variant of the ornament to the original motif, as shape and accuracy. The selected combination of tool and method was afterwards transferred to CNC Router and the ornaments were processed on wood surface. For a comparison from the aesthetic point of view, the same ornaments have been processed on laser beam equipment.

A CNC Router, model ISEL GFV, Eiterfeld, Germany was used for milling the ornaments and OmniBEAM 150 Laser Machining Tool (LMT), manufactured by COHERENT, INC., Santa Clara, California, United States with nitrogen assist gas was used for laser engraving the ornament on wood surface.

Maple wood (*Acer pseudoplatanus*) panels of 300 x 200 x 18 mm were used as ornamentation base. Before processing the ornaments, the panels were sanded with 80 grit size, so to obtain a good flatness of the surface, in the range ± 0.15 mm.

The selected traditional motifs were designed using CorelDraw software, and the results are shown in Figure 2 (a1 and b1). The CDR vector file formats were converted to DXF files in AutoCAD and the results are shown in Figure 2 (a2 and b2). These files have the suitable format for importing them in VCarvePro 9.519 software for the simulation process.

The simulation software allows two type of processing methods on wood surfaces, namely ”Engrave”, with a constant cutting depth of 3 mm for the contour, which can be applied both to closed or opened contours of the drawing, and ”V-Carve”, with cutting depth between 1 mm and 3 mm for the surface and 3 mm for the contour, which can be applied only for closed contours of the drawings. In case of thin contour lines, the two methods can be combined.

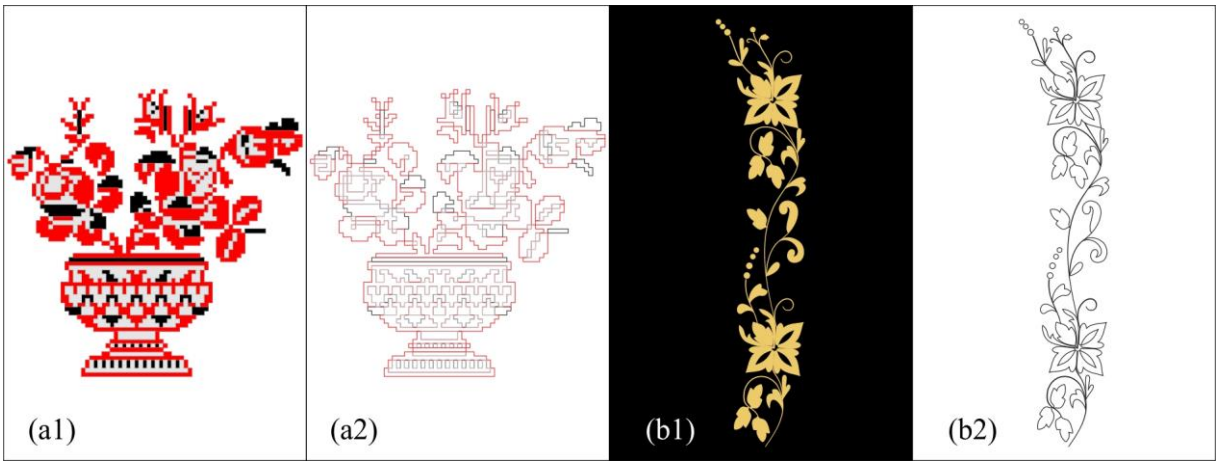

Figure 2. The drawings of the traditional motifs: (a1, a2) – Model 1, (b1, b2) – Model 2.

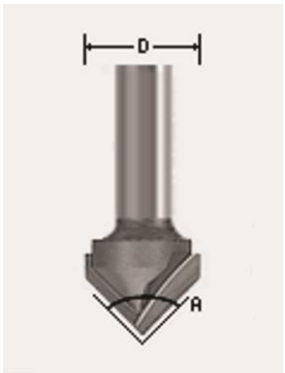

Figure 3. Tool used for router milling of wood.

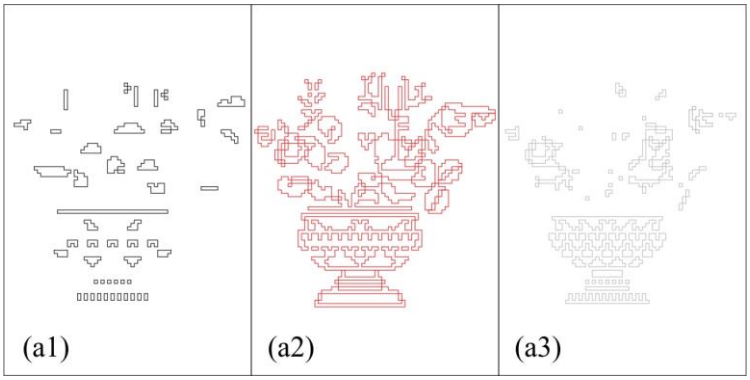

Figure 4. Decomposition of Model 1 into colours: (a1) – black, (a2) – red, (a3) – white.

V groove router bits tools (Figure 3) angled 90° and 120° respectively, have been used for the simulation and CNC routing. Cutting depth, feed speed and spindle rotation speed have been set up, as presented in Table 1. These tools are recommended for engraving and plane bas-relief, which is the type of ornament suitable to transfer the textile motifs on wood surface. These types of ornaments require low cutting depths and high feed speeds during processing them on wood surfaces, and these characteristics are fulfilled by the selected tools.

Table 1. Milling parameters set up.

Included angle A (degrees)	Diameter D (mm)	Spindle speed (r.p.m.)	Pass depth (mm)	Feed rate (m/min)	Plunge rate (m/min)	Clearance pass (mm)
90	32	15000	3	6	6	0.5
120	32	15000	3	6	6	0.5

The DXF format files resulted from AutoCAD have been also imported in LaserLink™ software, which creates files that runs the Coherent OmniBEAM in the LMC format, containing the tool paths and the process parameters that run an efficient laser machining job. Because the original motif of Model 1 has three colours in its composition, it was decomposed in three files, one for each colour, as seen in Figure 4, and for each file different parameters were set up for laser beam, in order to obtain different intensities of the colour resulted from burned wood. These parameters are presented in Table 2.

Table 2. Laser engraving parameters set up.

Motif	Power (% of Laser Power)	Power (W)	Feed, (m/min)
Model 1 – black	20	30	5.4
Model 1 – red	15	22.5	5.4
Model 1 – white	7	10.5	5.4
Model 2	15	22.5	5.4

3. Results and discussion

The simulation process has shown that V-Carve method was not a properly one, because the motifs have not been processed completely, because of the presence of open contours in the drawing. With combination of V-Carve and Engrave methods, the ornaments looked very crowded.

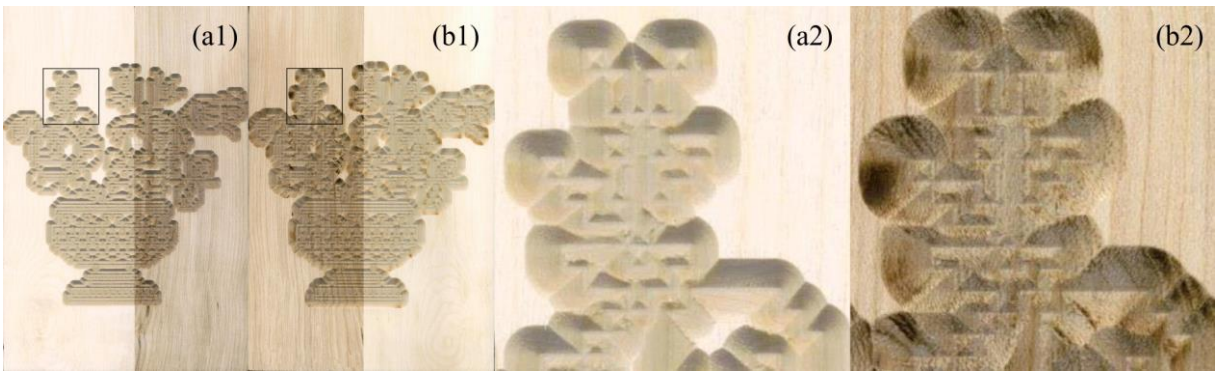

Figure 5. Router milling of Model 1: (a1) – Engrave 90°; (a2) – Detail for Engrave 90°; (b1) – Engrave 120°; (b2) – Detail for Engrave 120°.

Applying Engrave method for the real processing on CNC Router, had as result the images in Figures 5 and 6, a1 and b1, where noticeable differences were observed for using V-tools with different angles of 90° and 120° (as seen in details a2 and b2 from Figures 5 and 6). The trace of the 120° angled tool on the ornament looked wider and more crowded than that of the 90° angled tool.

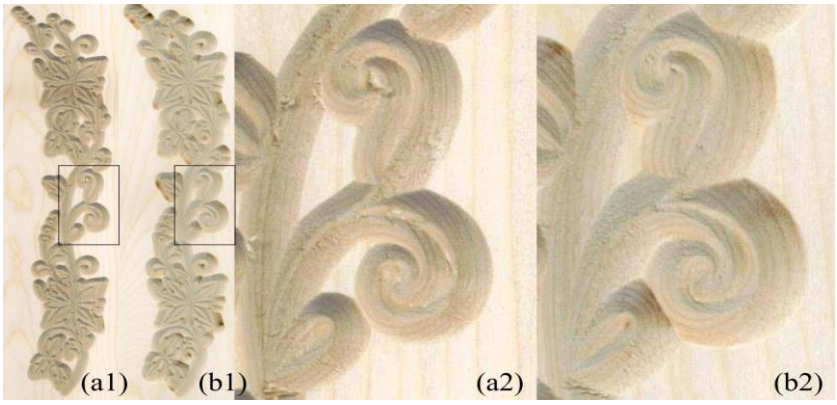

Figure 6. Router milling of Model 2: (a1) – Engrave 90°; (a2) – Detail for Engrave 90°; (b1) – Engrave 120°; (b2) – Detail for Engrave 120°.

BeamHMI software was used for the laser engraving of the two motifs. The resulted ornaments are presented in Figures 7 and 8. The three layers of the Model 1 were processed one by one without moving the wood piece and the total recorded processing time was the sum of the three ones (black + red + white = 13:47 + 25:02 + 18:33 min:s). The processing times for each model and method are shown in Table 3.

Figure 7. Laser engraving for Model 1.

Figure 8. Laser engraving for Model 2.

Table 3. Processing times.

Model	Method	Tool	Processing time, min:s
Model 1	CNC Router engraving	V-bit 90°	14:52
	CNC Router engraving	V-bit 120°	14:52
	Laser engraving	Laser	57:22
Model 2	CNC Router engraving	V-bit 90°	6:30
	CNC Router engraving	V-bit 120°	6:30
	Laser engraving	Laser	27:50

Processing times are connected to productivity first, and tool wear in case of CNC routing. Even if the processing times are longer for Laser engraving than in case of CNC engraving, the laser ornaments win through their aesthetic appearance, so the selected method is a compromise between aesthetic and costs.

4. Conclusions

This study presents the methods used to transfer the traditional motifs collected from the textile heritage to the decoration of the furniture wood surfaces, based on advanced software tools, and to perpetuate the traditional motifs and their symbol values to next generations.

The simulation software of CNC Router offers the possibility to select the appropriate tools and methods and to eliminate the unsatisfactory variants. The experimental work provides the complete image of aesthetic, surface quality and technological costs. The final decision is a compromise between them.

Further experimental work will investigate the quality of the processed surfaces in terms of roughness measurements for various species of wood and engineered wood products.

Acknowledgments

The authors thank Dan Petrea for his work with milling processing and Dr. Alexandru Stănescu for providing the photos with the two models.

ORCID iDs

A Lungu http://orcid.org/0000-0001-8266-5230
L Gurău http://orcid.org/0000-0001-9998-6671
S Georgescu http://orcid.org/0000-0002-3660-0265
C Coșereanu http://orcid.org/0000-0002-5805-8315

References

[1] Chernykh M, Kargashina E and Stollmann V 2018 *Acta Facultatis Xylologiae* **60** (1) 121-7 https://doi.org/10.17423/afx.2018.60.1.13
[2] Petru A 2015 Image Conversion for laser pyrography *Pro Ligno* **11** (4) 646-53
[3] Liu Q, Yang C, Xue B, Miao Q and Liu J 2020 *BioResources* **15** (3) 5366-78 https://doi.org/10.15376/biores.15.3.5366-5378
[4] Gurău L and Petru A 2018 *BioResources* **13** (4) 8168-83 https://doi.org/10.15376/BIORES.13.4.8168-8183
[5] Gabdrakhmanov A T, Bobrishev A A and Shafigullin L N 2019 *IOP Conf. Series: Materials Science and Engineering* 481 012045 https://doi.org/10.1088/1757-899X/481/1/012045
[6] Paiu I, Androne A and Coșereanu C 2020 *Pro Ligno* **16** (3) 60-7
[7] Hazır E and Koc H 2016 Optimization of wood surface machining parameters in CNC routers: Response surface methodology (RSM) approach *International Journal of Scientific Research Engineering & Technology* **5** (10) 494-501 Corpus ID: 189759102
[8] Aghakhani M and Khazaeian A 2014 *Asian Journal of Agriculture and Food Sciences* **2** (6) 548-53 https://ajouronline.com/index.php/AJAFS/article/view/2073
[9] Kazlauskas D, Jankauskas V, Bendikienė R, Keturakis G and Mačėnaitė L 2017 *Mechanicka* **23** (3) 469-72 https://doi.org/10.5755/j01.mech.23.3.18482
[10] Laszewicz K, Górski J, Wilkowski J and Czarniak P 2013 *Wood Research* **58** (3) 451-64
[11] Sütçü A 2013 *BioResources* **8** (1) 795-805 https://doi.org/10.15376/biores.8.1.795-805