SIMULATING THE SURFACE OF LITCHI GRAIN LEATHER BY CREATING QUADRILATERAL-CONTINUOUS PATTERN IN ADOBE ILLUSTRATOR CC

Wei WANG[1, 3], Weijie WANG[3], Biyu PENG[1, 2], Luming YANG[1, 2*]

[1]Sichuan University, National Engineering Laboratory for Clean Technology of Leather Manufacture, South Section 1, Yihuan Road, No.24, 610065, Chengdu, China

[2]Sichuan University, Key Laboratory of Leather Chemistry and Engineering, 610065, Chengdu, China

[3]Sichuan University, Faculty of Textile and Garment Engineering, 610065, Chengdu, China

Received: 03.11.2018 Accepted: 05.02.2019 https://doi.org/10.24264/lfj.19.1.6

SIMULATING THE SURFACE OF LITCHI GRAIN LEATHER BY CREATING QUADRILATERAL-CONTINUOUS PATTERN IN ADOBE ILLUSTRATOR CC

ABSTRACT. The paper illustrates an approach of creating quadrilateral-continuous pattern for simulating litchi grain leather surface in order to solve the issue that the designer of leather products cannot simulate litchi grain surface simply or realistically. Adobe Illustrator CC is a kind of design software that possesses pattern-editing mode. Based on both the image of the litchi grain leather sample scanned by stereo microscope and the rationale behind the quadrilateral-continuous pattern, we obtained the wrinkles and pores of litchi grain leather sample in Adobe Illustrator CC without using any sophisticated algorithm, which in turn resulted in realistic and various effects on the surface of litchi grain leather. Moreover, the pattern exported from Adobe Illustrator CC can also be widely used in other kinds of design software.
KEY WORDS: litchi grain leather, quadrilateral-continuous pattern, Adobe Illustrator CC, surface simulation

SIMULAREA SUPRAFEȚEI PIELII CU MODEL ÎN RELIEF PRIN CREAREA UNUI MODEL PATRULATER CONTINUU ÎN ADOBE ILLUSTRATOR CC

REZUMAT. Lucrarea prezintă o abordare a creării unui model patrulater continuu de simulare a suprafeței pielii cu model în relief pentru a rezolva problema cu care se confruntă designerul de produse din piele care nu poate simula suprafața pielii în mod simplu sau realist. Adobe Illustrator CC este un software de design care permite modelarea tiparelor. Pe baza imaginii scanate la stereomicroscop a probelor din piele și pe baza raționamentului din spatele modelului patrulater continuu, am obținut „ridurile" și „porii" de pe suprafața pielii în Adobe Illustrator CC fără a utiliza niciun algoritm sofisticat, obținând efecte realiste și diverse pe suprafața pielii. În plus, modelul exportat din Adobe Illustrator CC poate fi folosit pe scară largă și în alte tipuri de software de design.
CUVINTE CHEIE: piele cu model în relief, model patrulater continuu, Adobe Illustrator CC, simularea suprafeței

SIMULER LA SURFACE DU CUIR EMBOSSÉ EN CRÉANT UN MOTIF QUADRILATÉRAL CONTINU DANS ADOBE ILLUSTRATOR CC

RÉSUMÉ. Cet article présente une approche permettant de créer un motif quadrilatéral continu pour simuler une surface de cuir embossé afin de résoudre le problème selon lequel le concepteur de produits en cuir ne peut pas simuler de manière simple ou réaliste une surface de cuir embossé. Adobe Illustrator CC est une sorte de logiciel de conception doté du mode d'édition de motifs. Sur la base de l'image de l'échantillon du cuir scanné au stéréomicroscope et de la logique du motif quadrilatéral continu, nous avons obtenu "les rides" et "les pores" de l'échantillon de cuir embossé dans Adobe Illustrator CC sans utiliser d'algorithme sophistiqué, en obtenant des effets réalistes et variés sur la surface du cuir embossé. De plus, le motif exporté depuis Adobe Illustrator CC peut également être largement utilisé dans d'autres types de logiciels de conception.
MOTS CLÉS: cuir embossé, motif quadrilatéral continu, Adobe Illustrator CC, simulation de la surface

* *Correspondence to: Luming YANG, Sichuan University, National Engineering Laboratory for Clean Technology of Leather Manufacture, South Section 1, Yihuan Road, No.24, 610065, Chengdu, China, ylmll1982@126.com*

INTRODUCTION

Litchi grain is one of the most popular leather knurling textures which show a stereoscopic, roughened, distinct leather surface. Litchi grain leather (LGL) has characteristics of being soft, durable, comfortable and is commonly used for making leather products. It burnishes and beautifies as time goes by, developing a sought-after patina with unique character that can not be easily duplicated. This predicament occurs when designers simulate LGL merchandise and is used for texture mapping. It is a slow process and difficult to simulate the grained surface as it consistently looks artificial and unrealistic as well.

The texture synthesis technique is the best tool to solve these issues [1]. Some approaches that have been proposed for leather texture synthesis are physical simulation [2], which synthesizes the leather texture by directly simulating its physical generation processes and can model using cellular texturing [3, 4] as well as reaction diffusion [5, 6]. These techniques can generate textures directly with an efficient algorithm, but it is difficult for leather products designers to design an algorithm.

We hypothesise that the quadrilateral-continuous pattern (QCP) of LGL could be generated by a generic software, which could generate a unit that represents the appearance and structural elements of the LGL surface. The visualization, texture mapping and rendering of the LGL merchandise will be accelerated and more convenient.

The solution described in this study addresses the realistic requirement to accurately generate a vector quadrilateral-continuous pattern of LGL utilizing Adobe® Illustrator® (AI). An important attribute of such a continuous unit can be fast and efficient for leather products designers. Furthermore, this kind of vector quadrilateral-continuous pattern will not be distorted, the parameters can be transformed and the pattern can be modified to other appearances automatically and subtly. Moreover, the LGL quadrilateral-continuous pattern made by AI can be saved as many corresponding formats with high resolution, in order to use it for other software.

EXPERIMENTAL

Materials

Olympus SZX12 stereo microscope, equipped with a full-fledged optical system featuring a zoom ratio of 13, in order to obtain skeletons with informative LGL surface structural elements for referencing.

MShot Digital Imaging System, a program designed for a microscope camera to connect with the computer in order to view, capture, measure and process the LGL surface.

Adobe Illustrator CC, QCP of LGL can be customized from scratch with many tools in Adobe Illustrator.

Methods

Obtaining Referenced Skeletons

Olympus SZX12 Stereo Microscope equipped with a full-fledged optical system featuring a zoom ratio of 13 was utilized. There was a collaboration between the MShot Digital Imaging System v1.0 connected with the stereo microscope and the computer in order to view and capture the LGL surface. Figure 1 is a scanned piece of the LGL sample image under 10 times the stereo microscope. Lines and points were generated which represent skeletons in order to analyze and extract informative LGL surface structural elements (i.e. cristae, sulci, wrinkles, pockets and pores) for referencing [7, 8].

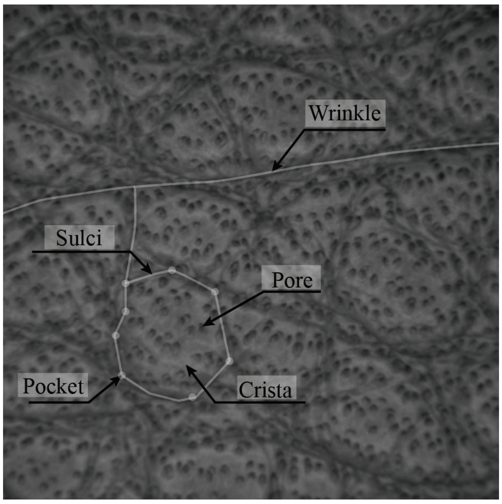

Figure 1. Scanning LGL sample image under 10 times the stereo microscope

Rationale of the Quadrilateral-Continuous Pattern

The quadrilateral-continuous pattern, also known as seamless repeat pattern or pattern tile, is a small artwork repeated next to each other in a seamless way that appears to be one single artwork. Figure 2 is an illustration of the rationale generating QCP, as an ordinary triangle was used as the element in this paradigm.

The broken lines represent the pattern bounding box which is an unfilled and unstroked (non-printing) rectangle. For filling patterns, the bounding box acts as a mask and defines a portion of the pattern tile which indicate that the fragmentary triangle on the right inner side should be completed on the left inner side. The same goes for the top and bottom positioning. After perfecting some details, a triangle quadrilateral-continuous pattern will be generated and appears repetitively without any flaws [9, 10].

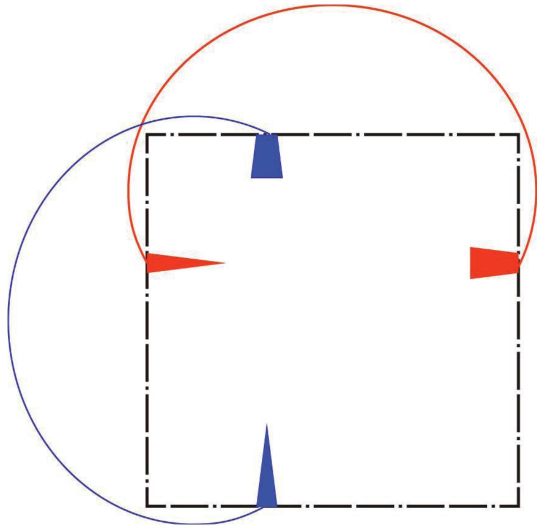

Figure 2. Illustration of the rational generating seamless repeat pattern

Rationale of Generating QCP in AI

According to the rational above, the production of the quadrilateral-continuous pattern was not always an easy task, requiring precision and patience. Nevertheless, with AI CS6 and later version CC, this process became automatic and accelerated. The pattern design tools are accessed through a new menu item: Object > Pattern > Make. Designers are taken into a new pattern generation mode, controlled by a new Pattern Options panel which offers a greater level of control over patterns.

The benefits of generating QCP by AI are not only described above but also because designers can set the repeating behavior by 5 tile type options in the Tile Type pull-down (i.e. Grid, Brick by row, Brick by column, Hex by column, and Hex by row) without having to figure out the algorithm that is needed to do it manually. These tile types enrich the style of SPR.

The Grid tile type follows the rationale of QCP described above, because of this, the Brick Offset value could be changed in Brick by row and Column which can interactively tweak the effects of Grid tile type. Moreover, the bounding boxes of Hex tile type have two more boundary handles than Grid type, a shape of hexagon thatcan create more varied effects. Figure 3 presents the pattern operation interface that contains tile types in AI and the differences of bounding box and rationale between grid tile type and hex tile type.

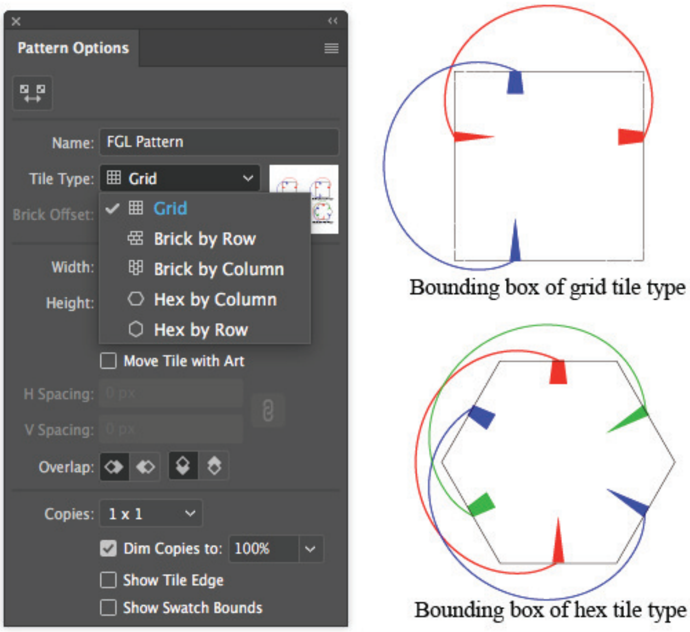

Figure 3. Pattern operation interface of AI & Different bounding boxes and rationales of grid tile type and hex tile type

Generate Wrinkles of LGL Surface

Following the operation procedures give instructions about generating the Grid type QCP of LGL surface as a paradigm using the latest version CC of AI. Brick type and Hex type are based on Grid type and after knowing the principle of generating Grid type pattern, it is easy to generate the other four kinds of QCP in AI. Keyboard shortcuts in brackets are given in this study.

Open Adobe Illustrator and create a new document named QCP of LGL (Cmd/Ctrl + N). Set the units as pixels, color mode as RGB and raster effects as 300 ppi. Place the scanning stereo microscope image into the document (File > Place > Embed). The skeleton of LGL will be extracted from referring to this image.

Based on the size of the placed raster scanning stereomicroscope image, create a rectangle using the Rectangle Tool (M) and set both the fill color and stroke color to None. Select the image and rectangle and set the Align as Horizontal Align Center and Vertical Align Center. This rectangle will play a crucial role when coloring the underpainting of LGL.

Select the image and rectangle, then go to Object > Pattern > Make, which changes to Pattern Editing mode. Lock the two layers and set the stroke color as R=25, G=25, B=25. Select the Tile type as Grid, overlap as Left in Front and Top in Front. Use the Copies pull-down to add repeats which can control the visibility (dimming, edges and bounds) of pattern tile, and keep these settings as the defaults. There will be a rectangle with the same size of the image which plays the role of the boundary box. Continue creating the skeleton of wrinkles while referring to the wrinkles on the bottom image with the help of the Pen Tool series (P).

In this mode, paths of wrinkles can be created inside the boundary box from left/top to right/bottom. The portions outside the right edge/bottom edge of the boundary box will be completed inside the boundary box from left/bottom. Meanwhile, the initial anchors and terminal anchors will be assembled on the left edge and top edge. Take advantage of these conveniences and automations; adjust the paths in order to make sure uniformity, continuity and extensibility with paths on adjacent tiles on the premise that there are no significant changes compared with referencing wrinkles, especially the anchors assembled on the boundary box edges.

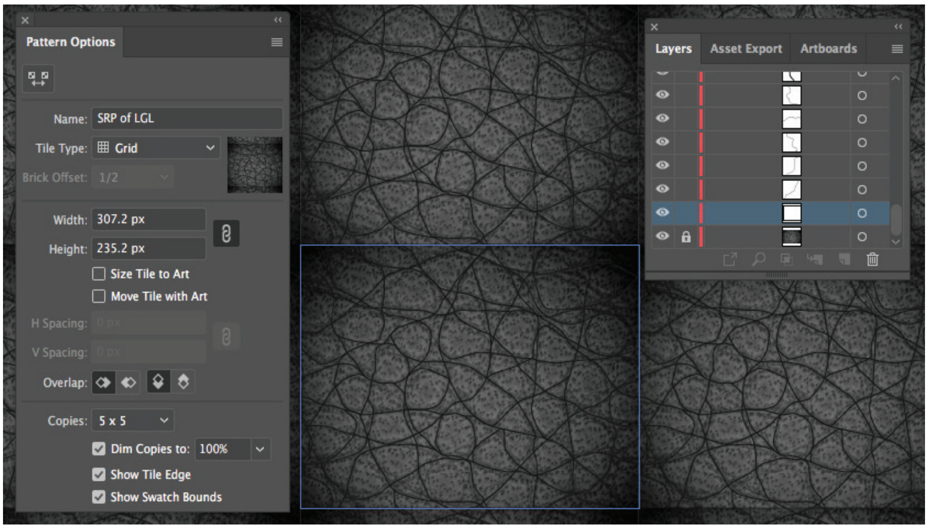

Figure 4. Extact skeleton of wrinkles in AI pattern editing mode

With the observation of wrinkles, the widths of the them are observably changeful. In order to generate this effect, create a calligraphic brush in the Brushes Panel with the parameters as Angle=45°, Roundness=35% and Size=2 pt. Select all the created paths and click the new brush in Brushes Panel, resulting in the paths turning into diverse wrinkles immediately.

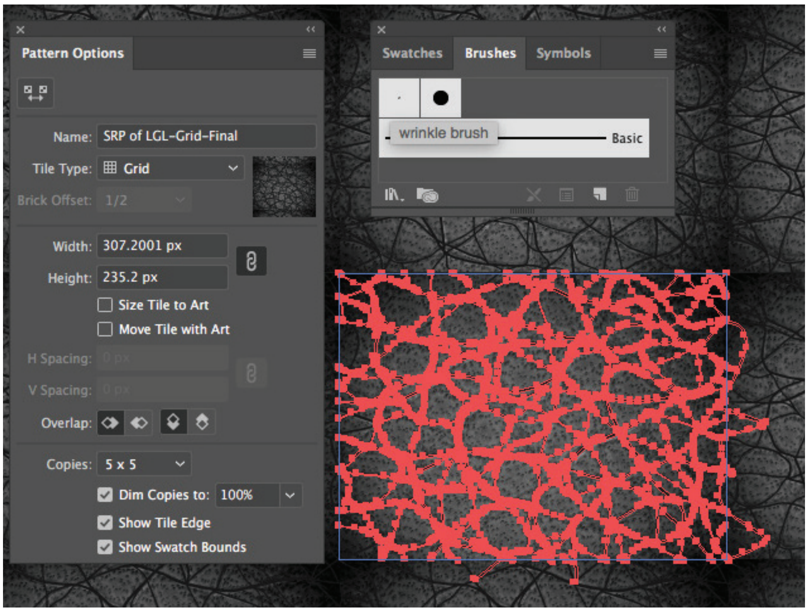

Figure 5. Simulate wrinkles of LGL using paths and calligraphic brush

With the aim of simulating more stereoscopic LGL surface effect, highlighting is an essential element. Select all the wrinkles, make a copy of them (Cmd/Ctrl + C) and paste in back (Cmd/Ctrl + B). Click the Transform Panel, add 2 px each on the X Value and Y Value and change the Fill Color into R=255, G=25 and B=255. Go to Pathfinder (Cmd/Ctrl + Shift + F9) and check the Unite option to create a compound shape. Open the Transparency Panel, set the Blending Mode as Overlay with Opacity=50%. Go to Effect > Stylize > Feather and set the Radius=2px. The setting of this process can create a more natural highlight effect and in addition, the overlay blending mode will eliminate the effect of highlights on the wrinkles of adjacent tiles.

Generate Pores of LGL Surface

The pores reveal uneven features on the LGL surface while utilizing the Symbol Sprayer Tool could express this feature quickly. First, enlarge the referencing image in order to observing the details of the pores. Use the Pen Tool to outline one of the pores' shape. Fill the gradient from white to black, adjust the angle consistent with the angle of the highlight by using the Gradient Tool whose type is radial; Stroke in white and use the wrinkle brush that was created earlier; set the Blending Mode as Overlay with Opacity=70%. Feather it with the Radius=1.5px and drag it into the Symbols Panel, naming it Pore. These parameters can be seen in the Appearances Panel in Figure 6. The setting of this process can create a more natural pore effect.

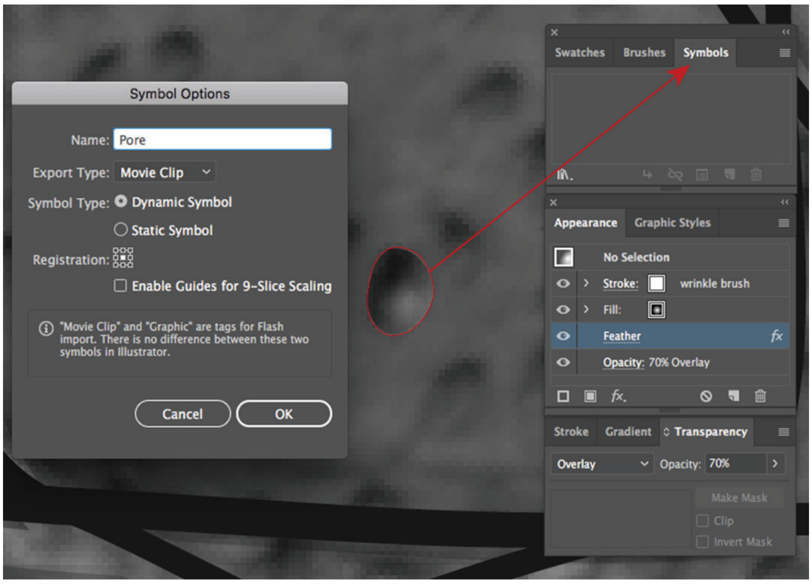

Figure 6. Simulate pores symbol of LGL referring to the realistic feature

Select the Pore symbol created earlier and use the Symbol Sprayer Tool (shift + S) and other subtools to spray and adjust the pores. Double click the Symbol Sprayer Tool and set the parameters of Intensity and Symbol Set Density while keeping the other options as default. With the purpose of keeping the integrity of all pores, do not spray them on or outside the left and top edge of the boundary box, Press the Option/Alt key and use the Symbol Sprayer Tool to erase them when it happens; however the Pore symbol can be sprayed beyond the right and bottom edge while the excessive portions appear inside the boundary box on the opposite direction simultaneously. Use the Symbol Shifter, Scruncher and Sizer Tool to adjust the size and density of the pores. This process can be accomplished in a few steps in order to adjust the pores with different sizes separately as well as show different density.

Finally, delete the raster scanning stereomicroscope image in the last layer and fill the rectangle at penultimate layer color with any RGB, except with the same color as the wrinkle. Highlight and click on the Done button. The new seamless pattern has been saved in the Swatches panel. Save it in the root directory, allowing it to be used as a fill for any objects in AI in the future.

Generate Tiles of LGL Surface Used in Other Software

The format of PNG, which owns transparent background, is necessary in order to expand the application of QCP of LGL in other software such as texture mapping of a three-dimensional design. Drag the new pattern from the Swatches panel to the artboard where several tiles will splice together. Ungroup these objects select the rectangle, which acts as the boundary box in the center, and bring it to the front (Cmd/Ctrl + shift

+]). Select all of the objects, go to Pathfinder (Cmd/Ctrl + shift +F9), and click on Crop option. Objects outside the boundary box will be deleted directly and the parameters of the highlights and pores should be set again as Blending Mode is Overlay, Opacity=70%. After go to Effect > Stylize > Feather, and set the Radius=1.5px. Delete the entire highlight if the pattern tile is used in three-dimensional software. Finally, go to File > Export, and export the tile as PNG format.

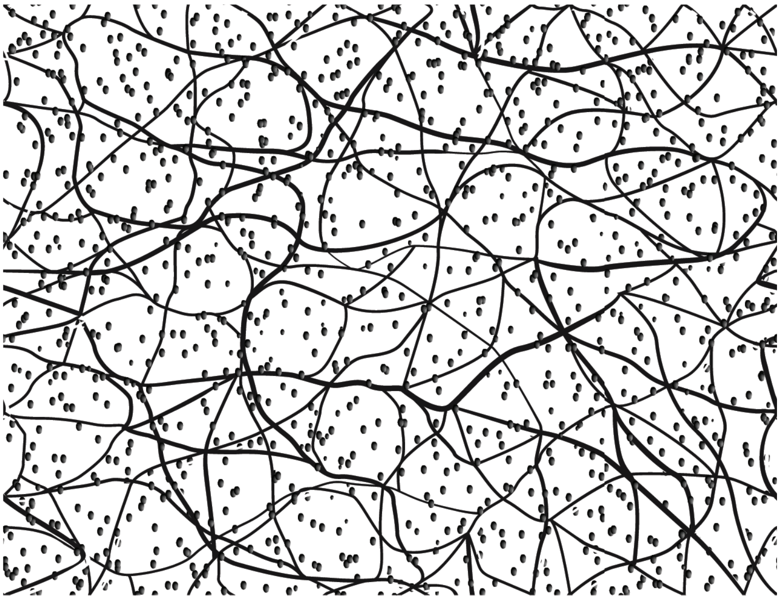

Figure 7. PNG pattern tile exported from AI with transparent background

RESULTS

Based on the stereomicroscope image of LGL, the method of generating Grid type QCP of LGL in AI using the Pattern Editing Mode could simulate the stereoscopic characteristic of LGL surface easily and quickly.

Except for Grid tile, the position of pattern tiles could be offset horizontally, vertically, or hexagonally using the type of Brick by row, Brick by column, Hex by column, and Hex by row in the Pattern Option panel, which could generate more varied QCP of LGL.

Besides the finding that designers can modify and transform the scale, the angle of litchi grain conveniently resulting from the properties of vectorial graphics made in AI could simulate various appearances of LGL surface. Moreover, the other format files exported from AI could be used for texture mapping and rending with high resolution in three-dimensional leather products design.

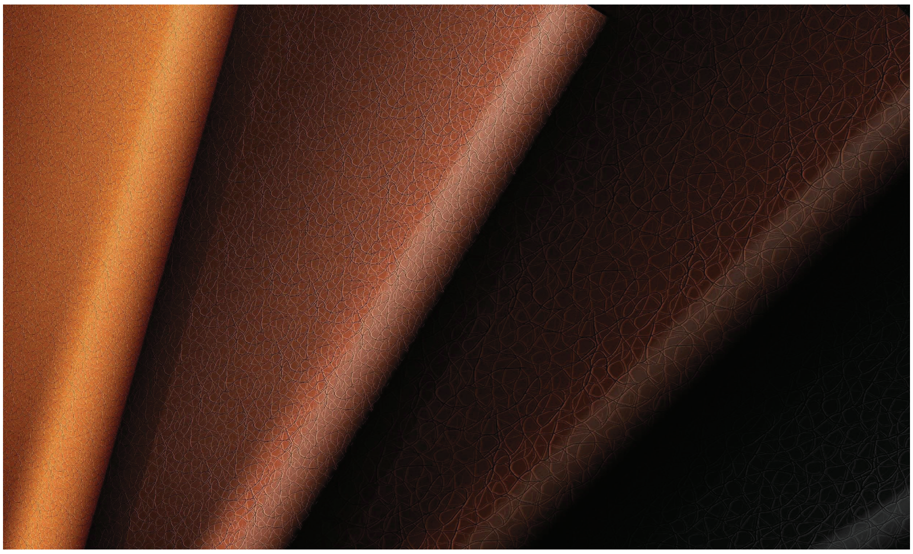

Figure 8. Different appearances of LGL filled with QCP generated in AI

DISCUSSION

The main goal of this study was to attempt to find a way to simulate the LGL products with realistic appearances efficiently. When comparing our results with studies by Miyata *et al*., a method for generating leather texture by means of particle simulation and blobby model were introduced [4, 8, 11]. This method initiatively generated a cell arrangement pattern using a 3D particle model while the detailed surface geometry was then created by applying a blobby model. Users could create various types of realistic leather textures with ease by simply choosing a cell arrangement type and selecting directionality for each section, along with inputting control parameters in the texture generator.

Similar with the methods of Miyata, Sakurai *et al*. described a method for procedural leather texture generation focusing on structural leather elements and based on Voronoi diagrams and mass-spring model [7, 12, 13]. They explicitly tried to simulate realistic leather with a continuous surface by forming pores and sulci by modifying the nodes of the diagram and applying radial basis function, respectively.

Although the work of research discussed above have provided solutions to solve these issues, it has been very difficult for leather products designers to design an algorithm that is both efficient and capable of generating a high quality continuous LGL tile, as well as input it to professional and generic software to use. The methods introduced in this study adopted the generic software with the Pattern Making Mode, which consists of Grid Tile, Brick Tile, and Hex Tile and could create various surface appearances of LGL quickly and effectively without using an algorithm. In addition, this method comes with all the advantages of vectorgraph properties, such as large-scale coverability, transformability, and easy-modifiability.

There were also limitations in this study. First and most importantly, the repetition of LGL patterns looked apparent and distracting when objects were zoomed out to a certain degree. This resulted from wrinkles that should be compensated and adjusted when creating the QCP using any Tile type, as only one portion of the LGL surface was referenced. Several stochastic algorithms were introduced to non-periodically tile the object with a small set of Wang Tiles [14], consisting of square tiles with color-coded edges, in order to create large expanses of complex patterns without an obvious repetitive feature [15]. In addition, with blur texture on the surface of LGL, the captured image shows thick or thin texture and color difference, as it was difficult to capture precise features with the observance of the naked eye, even though the referencing image was under the stereomicroscope. Some researchers use the canny edge detection operator and watershed algorithm [16] to extract the texture of the leather image. Canny operator can effectively extract the main texture, while the watershed algorithm can fully express the texture details. These methods can effectively extract the texture information from the leather image.

Future work in this study could combine the advantage of generating QCP in AI, algorithm design, and texture extraction methods in order to simulate surface of LGL without obvious repetitive trail when zoomed out it in any degree. Furthermore, future work is needed to simulate surface of LGL precisely according to the data calculated by the texture extraction methods.

CONCLUSION

The difficulty of simulating realistic LGL surface limits the creations of leather products designers. Fortunately, the application of generating QCP in Pattern Editing Mode created by AI solved this issue without using any algorithm. The generations of QCP used in LGL products design sketch were no longer time consuming and the surfaces of LGL did not appear to be artificial as the simulation referencing the scanning LGL sample image under 10 times the stereomicroscope. The efficiencies of creation, modification and transformation could be improved as well as the pattern tile exported from AI, which showed excellent effect when mapping texture in three-dimensional software.

REFERENCES

1. Kaufman, A., Azaria, S., Texture synthesis techniques for computer graphics, *Comput Graph*, **1985**, 9, 2, 139-145, https://doi.org/10.1016/0097-8493(85)90021-4.
2. Wei, L.Y., Levoy, M., Fast texture synthesis using tree-structured vector quantization, Proceedings of the 27th annual conference on Computer graphics and interactive techniques, **2000**, 479-488, https://doi.org/10.1145/344779.345009.
3. Worley, S., A cellular texture basis function, Proceedings of the 23rd annual conference on Computer graphics and interactive techniques, **1996**, 291-294, https://doi.org/10.1145/237170.237267.
4. Miyata, K., Sakaguchi, Y., Imao, K., Hatada, Y., Fujita, A., Suzaki, R., Leather texture generation, ACM SIGGRAPH 2006 Research posters, **2006**, pp.93, https://doi.org/10.1145/1179622.1179729.
5. Witkin, A., Kass, M., Reaction-diffusion textures, ACM SIGGRAPH Computer Graphics, **1991**, 25, 4, 299-308, https://doi.org/10.1145/127719.122750.
6. McCartney, J., Hinds, B.K., Zhang, J.J., Leather texture synthesis and rendering, *Comput Graph*, **1994**, 18, 1, 87-92, https://doi.org/10.1016/0097-8493(94)90119-8.
7. Sakurai, K., Miyata, K., Kawai, N., Matsufuji, K., Procedural modeling of leather texture with structural elements, Eurographics Conference on Natural Phenomena, Eurographics Association, **2009**, pp.1-8.
8. Miyata, K., Procedural Technology and Creativity Mining, 2012 Seventh International Conference on Knowledge, Information and Creativity Support Systems, IEEE, **2013**, pp.169-174.
9. Yamada, T., Hashimoto, A., Adachi, F., Shimohara, K., Tokunaga, Y., A method of generating seamless texture using GA, *Systems and Computers in Japan*, **2004**, 35, 2, 91-99, https://doi.org/10.1002/scj.1229.
10. Yamada, T., Hashimoto, A., Shimohara, K., A method of generating seamless textures using a multi-distance co-occurrence matrix and natural texture, Electronics and Communications in Japan (Part II: Electronics), **2004**, 87, 12, pp.28-37, https://doi.org/10.1002/ecjb.20133.
11. Miyata, K., Sakaguchi, Y., Imao, K., Suzaki, R., A Method of Leather Texture Generation

using Particle and Blobby Model, *Ipsj Sig Notes*, **2006**, pp.13-18.
12. Sakurai, K., Miyata, K., Matsufuji, K., Kawai, N., Generation of Leather pattern with pores, *Ipsj Sig Notes*, **2007**, vol. 111, pp.109-114.
13. Sakurai, K., Miyata, K., Kawai, N., Matsufuji, K., Leather texture generation considering sulci flow, ACM SIGGRAPH 2007 posters, **2007**, pp.17.
14. Wang, H., Proving theorems by pattern recognition-II, *Bell Labs Technical Journal*, **1961**, 40, 1, pp.1–41, https://doi.org/10.1002/j.1538-7305.1961.tb03975.x.
15. Cohen, M.F., Shade, J., Hiller, S., Deussen, O., Wang Tiles for image and texture generation, *ACM T Graphic*, **2003**, 22, 3, 287-294, https://doi.org/10.1145/882262.882265.
16. Luo, L.P., Xu, P.H., Gao, X.K., Rui, Y.X., Wang, Y., Texture extraction based on leather image, *China Leather*, **2016**, 45, 5, 24-35.