

Urban Inspirations: Crafting Unique Texture Patterns for Car Interiors [†]

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Abstract: The appeal of a car's exterior often captures a customer's initial attention, but the interior ultimately seals the deal, creating a lasting connection between the customer and car. The interior quality plays a significant role in shaping the overall impression of a vehicle. Interior surfaces with tactile and visual qualities contribute to customer experience. Traditionally, automotive manufacturers have relied on natural grains, leather, and occasional geometric patterns to enhance the aesthetic appeal and tactile experiences of interiors. This study presents a novel approach to texture pattern design for automotive interiors. This method uses city maps from diverse locations as sources to create unique textural patterns. The process begins by capturing high-resolution images of city maps, selecting segments based on tessellation potential, applying abstraction and correction, cleaning the image to eliminate unwanted elements, and generating a 2D black-and-white pattern that simulates the texture when applied to the CAD surfaces of the interior components. This approach offers a unique alternative to the conventional practice of selecting texture patterns from the existing sources. This enables automotive designers to create signature texture patterns that differentiate between brands in a competitive market.

Keywords: automotive interiors; texture patterns; city maps; innovative design; tactile quality; brand identity



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1. Introduction

Automobiles have become an integral component of modern society, serving various purposes, including daily commutes, transporting goods, running errands, and vacation travel. The exterior of a car often plays a significant role in attracting customers, and the interior design often confirms their decision to purchase [1].

Most automotive interior plastic parts are treated with textures to enhance their appearance, feel, and functionality [2]. These textures can be found in a variety of finishes, including polished, matte, etched, geometric, leather, wood grain, and graphic patterns. These surface textures help conceal common defects in molded parts, such as flow lines, blush marks, sink marks, and shadow marks.

Research suggests that the perception of consumer products plays a significant role in the perceived quality. The interior of a car contributes significantly to this perception, and high-quality interiors are often associated with high-quality vehicles [2,3].

Traditionally, automotive manufacturers have applied typical textures, such as natural leather and geometric patterns, to the interior parts. However, limited research has been conducted on this topic. This study introduced an innovative approach for designing textures for interior parts using tessellation.

Tessellation is the process of creating uniform, square, or non-square tiles to fill a large surface without gaps or overlaps. In this study, it was used to generate patterns that can be applied to the components of car interiors as textures [4].

By utilizing the method described in this study, automotive designers and manufacturers can create exciting customization options for car interiors.

2. Literature Review

The limited availability of literature on the suggested method for designing the appearance of objects is a consequence of the fact that automotive designers and manufacturers do not commonly follow this approach. Nevertheless, the existing literature can be classified into four categories: automotive interior design, tessellation-related publications, the application of tessellation to non-automotive objects, and the general literature on textures.

2.1. Automotive Interior Sector

User satisfaction is a crucial element for automotive interiors and plays a significant role in determining their overall customer experience. The unique interior components of 30 vehicles were comprehensively analyzed, highlighting the potential of utilizing satisfaction models to enhance design variables and increase user satisfaction levels in the automotive industry [3].

Shen Yanto [5] proposed a tactile–haptic interface that can measure and verify the texture of automobile interiors. This interface utilizes a high-resolution optical tactile sensor and a haptic electro-tactile array. The tactile sensor is based on the principle of optical total internal reflection (TIR), and can accurately capture the surface texture of materials such as leather and fabric. The haptic device can create tactile sensations on the fingertip through a high-resolution electrode array. The combined tactile–haptic interface has the potential to improve the design of automobile interiors and enhance the grading and quantification of surface texture. The study also discusses related texture pattern identification and perceived stimulus quality. It provides calibration and experimental results that demonstrate the high performance of the tactile sensor and the effectiveness of the haptic device.

An optical TIR-based surface texture sensor is an effective tool for measuring and analyzing the textural properties of extensive automotive interior leather sample surfaces. This sensor can aid interior designers in evaluating and classifying the crucial textural features of automobile interior surfaces. The quality of an automotive interior's surface is a vital aspect of the overall vehicle quality, and the characteristics of the materials used on these surfaces influence the human perception of the vehicle's interior quality. However, the lack of accessible and reliable quantification tools necessitates the development of objective product designs and quality control metrics for vehicle interior manufacturing. The newly developed texture sensor is a customer-centric solution that can enhance the assessment and quantification of automobile leather/fabric surface textures, and significantly contribute to the design of automobile interiors [6].

Notably, the field of human–machine interaction in autonomous cars is progressing in an intriguing manner. In today's era, customer interactions with car interiors are of paramount importance. According to Damiani et al., it is crucial to provide a distraction-free environment for the user to ensure comfort and relaxation within a car [7].

2.2. Tessellation Art

There is abundant literature available on tessellation and its various applications in fields, such as mathematics, architecture, art, hobbies, and design. Chang (2018) explored the application of tessellation in architecture using computer technology, discussing various modes of tessellation, such as symmetry and periodic tessellation, aperiodic tessellation, fractal tessellation, and radial and spatial tessellation. The author also delves into the realm of three-dimensional tessellations and their applications in floors, windows, and modern architecture [8].

Liapi et al. (2017) discussed a uniquely defined approach that must be adopted when applying tessellation patterns to curved surfaces. Square-tile tessellation patterns are

mapped over curved surfaces to achieve the desired effect. The authors also discuss how this algorithm can be applied to solve real-world problems [9].

Cledumas et al. (2019) compared methods of applying tessellation patterns and highlighted that their proposed method is superior to the generic method of using polygons to define tessellation [10].

Dr. Hari Ramakrishna demonstrated the generation of various tiles and wallpapers created from tessellations with the help of developed graphic tools, as well as the generation of fractal patterns with the help of a designed graphic software tool [11].

In her research, Emily Bachmeier explained what tessellation is and its reference to Escher, using mathematical theorems to create tessellations close to Escher's designs [4].

Overall, the literature on tessellation highlights its versatility and potential for application in various fields.

2.3. Applications of Tessellations in General Objects

Wang et al. (2003) explored and examined a texture-mapping technique used to simulate soft and flexible fabrics. This technique diverges from conventional texture-mapping procedures by incorporating a grid as an intermediate space between the planar and fabric surfaces [12].

Reddy et al. (2023) scrutinized the impact of material properties on the topography of textured surfaces and presented a methodology to enhance the process in their publication [13].

2.4. General Application

Tactile stimulation is vital in daily life. While earlier studies suggested that smooth surfaces were deemed pleasant, and rough and stiff surfaces were considered unpleasant, the range of pleasant and unpleasant tactile experiences adds to the complexity of matter [1].

3. Methodology

The selection of cities from a particular country was finalized, and their topography was examined using Google Earth. A portion of the city was chosen based on the presence of an intriguing arrangement of buildings, roads, greenery, and diverse backgrounds. Four high-resolution images (with a size of 8194×4925 pixels, a resolution of 96 dpi, and captured from Google Earth) were captured for each city in question.

The process of creating a seamless texture involves a significant number of trials and errors. The achievement of a desirable texture pattern requires extensive experimentation. The following steps (Figure 1) provide a comprehensive overview of this process:

1. Open the city image in the Adobe Photoshop;
2. Transform the image into black and white;
3. The brightness and contrast should be adjusted to such a level that it will show a promising pattern;
4. Invert the image;
5. Adjust the brightness contrast once again to obtain the desired contrast in the pattern;
6. Use the 'Threshold' filter to obtain a binary black-and-white pattern into the image;
7. Adjust the brightness and contrast to obtain clarity in the image;
8. Appropriately crop (a part that has the potential to generate an exciting texture) part of the large image to generate a texture pattern;
9. Import it into CorelDraw (vector-based platform) to create a vector format element of the pattern;
10. Generate the vector elements out of the selected pattern;
11. Use the method to generate a tessellation pattern from these vector elements [14];
12. Create a tile of tessellated patterns [14].

This tile is the basis of the texture pattern that we want to project onto the surfaces of the automotive components.

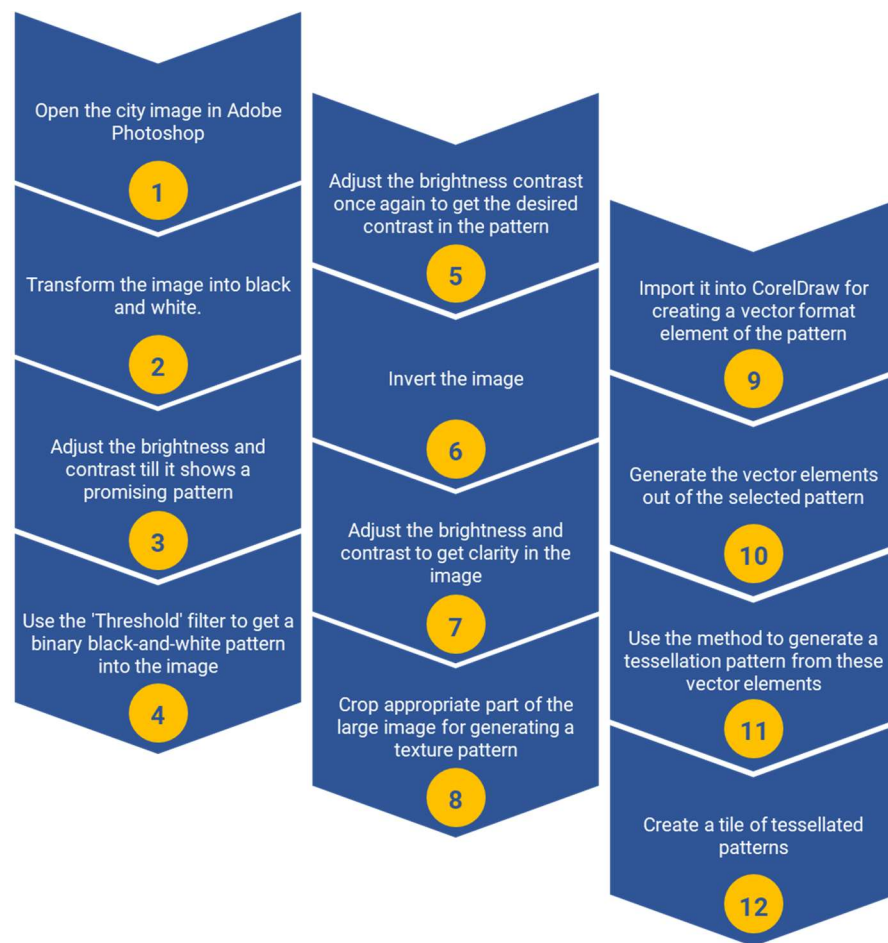


Figure 1. Flowchart of the steps for obtaining an abstract pattern for creating tessellation.

(The names of the software are written to provide an idea to the reader. There was no intention of advertising the software. One can use GNU software like GIMP (version 2.10.36) and Inkscape (version 1.3.2) to achieve the same effect with different sets of filters and plugins.)

We begin by capturing interesting images of cityscapes in India. These images were captured using Google Earth (Figure 2).



(a) City 01



(b) City 02

Figure 2. Cont.

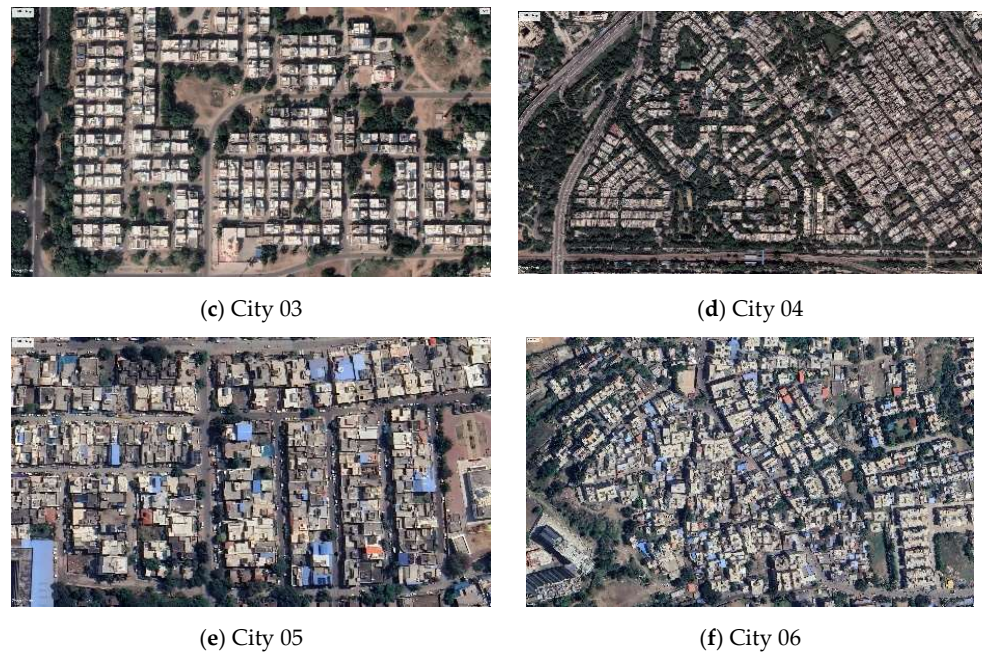


Figure 2. Six images of chosen cities [15–20].

After representing these cityscapes, we selected one of the images of interest from the six images given above. We then take this image through the process explained in Figure 1 and get the results below (Figures 3–8).



Figure 3. Part of the map of a chosen city (*name undisclosed to avoid bias*).



Figure 4. Image converted into black and white.



Figure 5. After corrections, and applying the 'Threshold' filter, the image is converted into a binary black-and-white pattern.

The generated tessellation pattern was subsequently used to produce digital representations of textures on the surfaces of interior components (Figures 9–11). This pattern is employed as a bump map in the color–texture shader employed by interior components, such as a dashboard, pillar trims, center console, or door trim. This realistic digital representation was created using Autodesk VRED Design 2023 software.

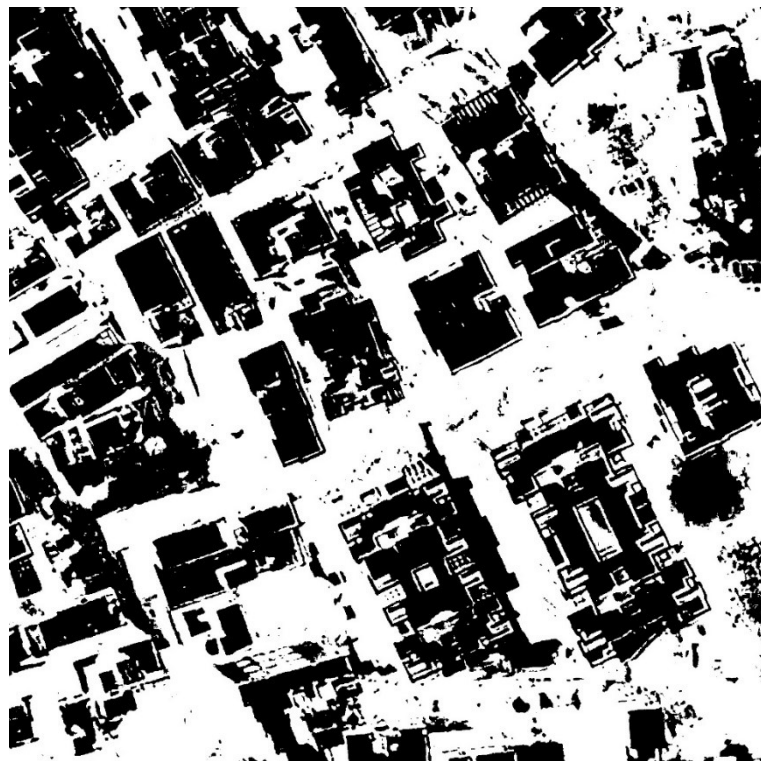


Figure 6. Cropped appropriate part of the large image for generating a texture pattern.



Figure 7. Vector elements generated for creating tessellation pattern.

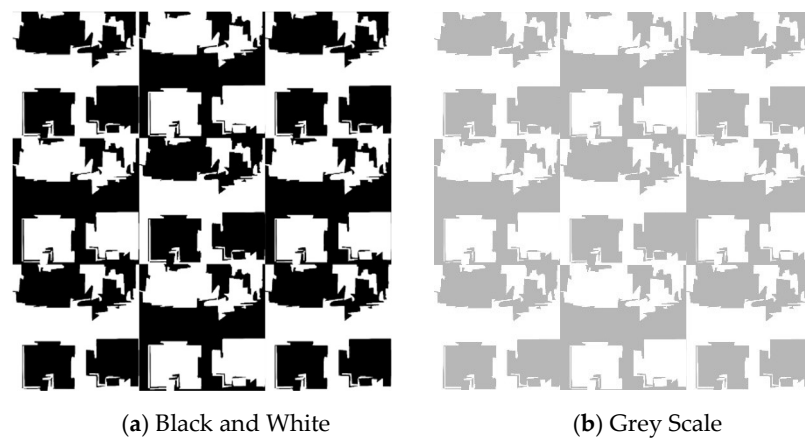


Figure 8. Tessellation pattern generated from the vector elements [14].



Figure 9. Representative dashboard mapped with the city texture car dashboard model [21].



Figure 10. Another view of mapped texture on the dashboard.

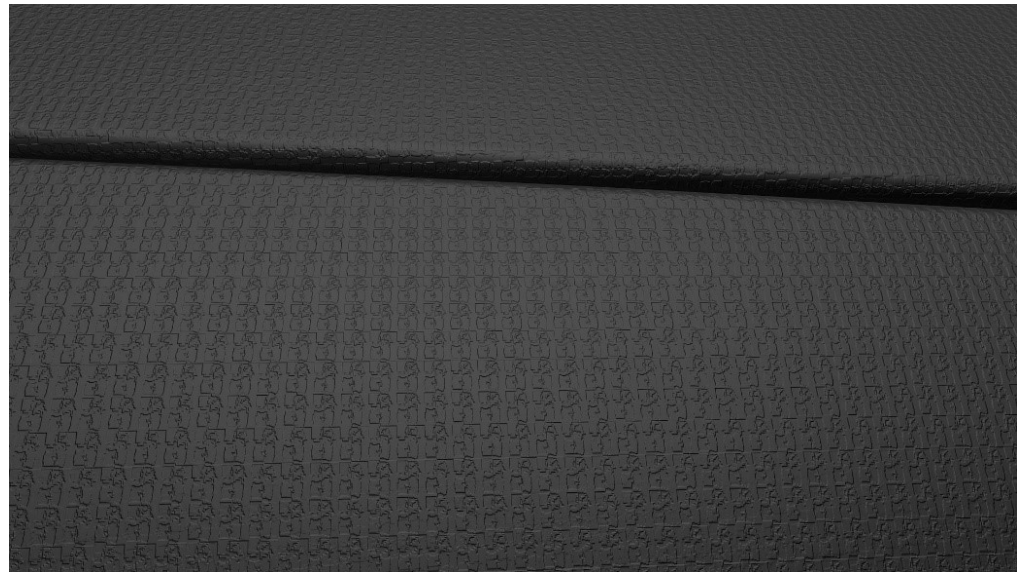


Figure 11. Zoomed image of the texture.

Figure 12 shows that the simulated texture on the car dashboard is the true representation of the tessellated image created for the texture. In Figure 12b, the two images at the top are semi-transparent to show the accuracy of the mapped texture, and the two images at the bottom are opaque, which represents the unit of tessellation.

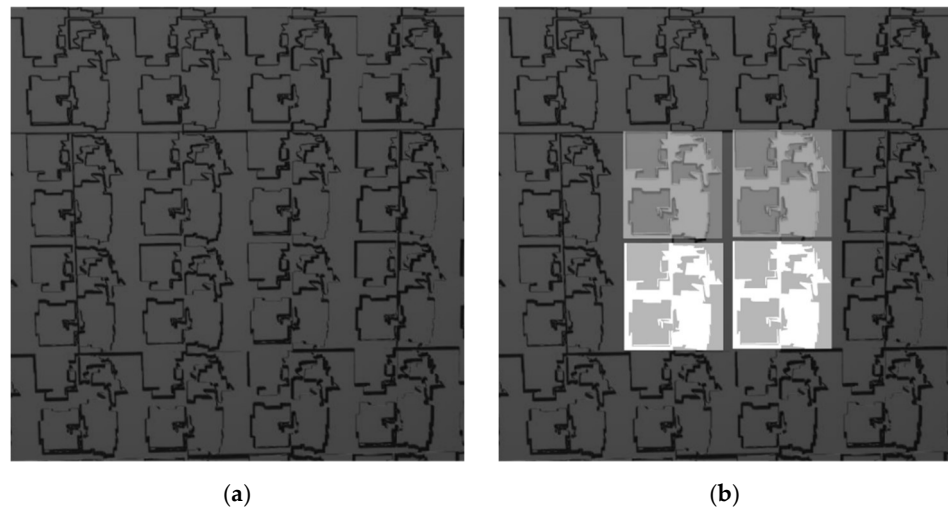


Figure 12. Comparison of the dashboard texture simulation and matching a part of tessellation pattern. (a) Dashboard texture simulation. (b) Tessellation pattern images superimposed on the dashboard texture.

4. Conclusions

The interior of the car extends beyond its physical dimensions and becomes an area where customers immerse themselves and demand careful attention to detail and sensory design. To achieve deep satisfaction, it is important to create an interior that fulfills individual preferences. Imagine owning a car with an interior tailored to your unique taste and preferences, offering a personalized driving experience.

An innovative way to achieve this goal is to incorporate tessellation patterns inspired by the country's dynamic cityscape. Such an approach not only adds personal pride to owning a car, but also brings a fresh perspective to the interior. By perfectly integrating elements of the urban landscape into the interior of the car, car designers can add

intrigue and playfulness to their creations, which elevates the driving experience beyond mere functionality.

This method offers car designers unparalleled creative freedom, allowing them to make connections between their daily lives and their vehicles. Thus, each journey becomes a unique and immersive experience that goes beyond the concept of a traditional vehicle as a means of transport. It is more than just design; it acts as a reflective canvas, illustrating the deep entanglement of our daily lives in the vehicles we choose to navigate. This symbiosis transforms the car into a dynamic expression of individuality and lifestyle, emphasizing the idea that a vehicle is not just a possession, but an extension of one's identity.

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