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Visualization for Texture Analysis of the Shitsukan Research Database Based on Luminance Information

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Abstract

Thus far, there were the difference meaning and interpretation for definition of "Shitsukan". Therefore, there were many studies whether "Shitsukan" can be evaluated quantitatively or not. As one of the past our study, we carried out texture analysis for classification method of texture types by using the Shitsukan Research Database. As a result, we were able to see characteristics between contrast and correlation for texture types. In this paper, we analyzed statistically after comparing between texture analysis for classification method of texture types and luminance information in the Shitsukan Research Database for the free of charge obtained from Web. And then, we obtained novelty and knowledge discussing characteristics of texture types.

Index Terms

Luminance, Image Database, H.265/HEVC, Gray-Level Co-Occurrence Matrix (GLCM), Heat Map

1. Introduction

"Shitsukan" is the wide variety of definition. Therefore, thus far, various methods were tried by the difference of research field. "Shitsukan" is defined as "material appearance, visualize and haptic feeling". On the other hand, "Texture" is defined as (1) fabric, (2) hand feeling of wood, stone, (3) use to represent object surface feeling as 3D CG image. Of course, it is possible to understand interpretation as definition of word. However, it is required to develop quantitative evaluation system by research fields in order that there is no numerical assessment and criteria that there is Shitsukan if how condition is needed.

In the broadcasting field, BS 4K broadcasting in 2018 is started. This is enabled to watch Quad FHDTV (QFHDTV: 4K) image quality four times more than that of Full HDTV (FHDTV). Furthermore, it is advanced increasing in display size by changing high definition of 2D/3D. Therefore, it comes possible to represent image and video dynamically, and then image texture is also improved. On the other hand, all playback contents are not always supported. Therefore, depending on the condition, appropriating of image processing technology such as 2K image quality contents upconverted by super-resolution, presentation clearly by contrast enhancement, which is needed to keep and improve original texture representation as possible. Overall, it is important for Shitsukan evaluation.

One of Shitsukan components is luminance. For an example, this is to adjust luminance to represent clarity, material feeling, and visual feeling of object surface. As our previous work, we experimented carrying out texture analysis and data mining for classification method of texture types using the Shitsukan Research Database. As a result, for texture type, it is seen for characteristics both contrast and correlation, however, it is not enough to consider for luminance information. Therefore, we consider that new knowledge is obtained by mutual comparison between luminance information and texture feature.

In this paper, first we set Shitsukan evaluation images encoded and decoded by H.265/HEVC in the Shitsukan Research Database from Web for free of charge, and then we processed quantification objectively based on texture analysis. Next, we compose heat map for luminance information from comparing between our result and luminance database, and then we discuss whether it is possible or not to understand characteristics and classify for Shitsukan or texture types by evaluating based on these maps.

2. Related Work

In this section, we describe dividing to "Color image engineering," "Computer graphics field," "Transportation and information system field," and "Medical image engineering field".

2.1. Color image engineering field

For color image engineering field, there are studies for texture model composition from optical approach, texture measurement. Most of these studies are measured in certain condition. On the other hand, these are estimated for Shitsukan by Kansei and impression evaluation from the view of human factor. However, these are not always assured for real-time because of depending on illumination environment and subjective evaluation.

2.2. Computer graphics field

For computer graphics field, there are studies as purpose to visualize and analyze Shitsukan or texture. These are discussed such as the following: the visual prototype composition based on fabric images, reflection and illumination, BRDF (Bidirectional Reflectance Distribution Function), multi-spectral light field, RGB-D camera, texture analysis for noise or fractal description, applied mathematics such as noise robust and rotation invariant framework, and signal processing and analysis for two-dimensional multiscale entropy.

2.3. Transportation and information system field

For transportation and information system field, there are studies on texture information analysis to process the road surface condition, environmental recognization, and environmental understanding. From this, it is important for real-time in this research field. These are discussed such as the following: the automatic classification for road environment, discriminant of wet condition for road video in night time, and rapid estimation of road friction for anti-skid automonous driving.

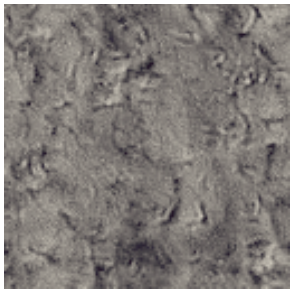

Figure 1. Evaluation image (bark)

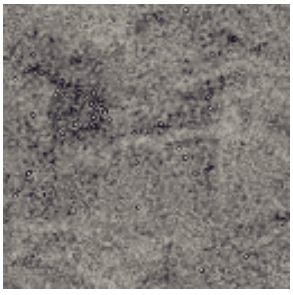

Figure 2. Evaluation image (sand)

Figure 3. Evaluation image (fabric)

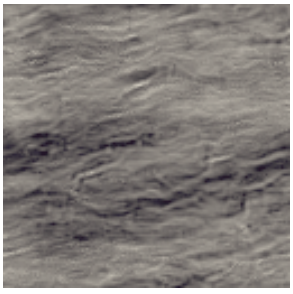

Figure 4. Evaluation image (fur)

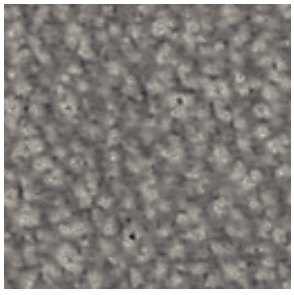

Figure 5. Evaluation image (leather)

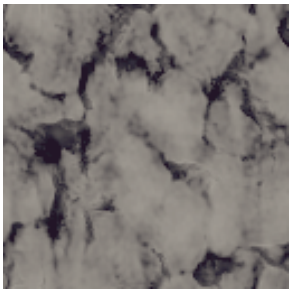

Figure 6. Evaluation image (stone)

Figure 7. Evaluation image (water)

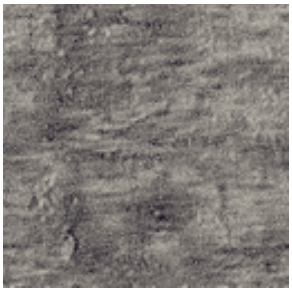

Figure 8. Evaluation image (wood)

2.4. Medical image engineering field

For medical image engineering field, it is required research content with better accuracy and certainly because there are many cases to touch human life and to need urgent. Under this condition, there are studies on texture analysis to detect the body region and lesion automatically. In this research field, these are discussed such as the following: the estimation causion of death, adaptive estimation of active contour parameter using convolutional neural network and texture analysis, and texture analysis of CT image in predicting malignancy risk of gastrointestinal stromal tumours.

2.5. Conclusion

Overall, it is not enough to be seen for study and case on measurement of Shitsukan or texture on real-time and large scale from information scientific approach and focus on image quality. Therefore, in this study, we purpose to obtain one of novel knowledge in the information science research field by verifying and clarifying the relation between luminance data and the Shitsukan Research Database.

3. Experimental Set

3.1. Evaluation images used in this study

Figs. 1 to 8 show the evaluation images of 4170 images in the Shitsukan Research Database encoded and decoded by H.265/HEVC for free of charge used in this study. There is eight types of Shitsukan such as "bark" (1-530), "sand" (531-992), "fabric" (993-1501), "fur" (1502-2041), "leather" (2042-2566), "stone" (2567-3091), "water" (3092-3629), and "wood" (3630-4170). For Quantization Parameter (Q), we used seven types: $Q = ref, 20, 25, 30, 35, 40, 51$. Table 1 shows the specification of evaluation images.

3.2. Experimental procedure

We show experimental procedure in the following (1) to (4).

(1). There are 10,355 images (included as 4,170 original images, 6,185 interpolation images by texture composition parameters) as overall for the Shitsukan Research Database. In this study, we experimented using 4,170 original images. On the other hand, in this study, we experimented using 4,170 luminance data.

(2). For 4,170 original images, we generate evaluation images encoded and decoded by H.265/HEVC. In this study, we use big data because there are 4,170 original images and 4,170 luminance data. Therefore, it is impossible for encoding and decoding by H.265/HEVC by image and luminance pattern, quantization parameter degree. For this case, we removed image pattern. On the other hand, in the case of missing and defect of encoding and decoding by H.265/HEVC, we included as evaluation images if it is possible to generate images.

(3). For generated evaluation images, we carried out the texture analysis, and then we compare to luminance data. In detail, we will explain in Subsection 3.3.

(4). Based on texture analysis result including luminance information, we try to classify Shitsukan types in each texture features using heat map for luminance information, and finally discussed this result. In detail, we will explain in Section 4.

3.3. Evaluation method

As the evaluation method in this study, we carried out image analysis using Gray Level Co-Occurrence Matrix (GLCM) which is one of texture features. Here, in case there is a gray scale image f (size $W \times H$ (pixels)) which is L level luminance value (gray level) as pixel value, row i column j component of GLCM V is

Table 1. Main specification of experiment

Image resolution	128×128 pixels
Contents type	bark (1-530)
	sand (531-992)
	fabric (993-1501)
	fur (1502-2041)
	leather (2042-2566)
	stone (2567-3091)
	water (3092-3629)
	wood (3630-4170)
Image coding	H.265/HEVC
	$Q = ref, 20, 25, 30, 35, 40, 51$

V_{ij}. In this case, we calculate in the following Eq. (1).

$$V_{ij} = \frac{\sum_{x,y \in \Omega} \left(\delta\left(i - f\left(x,y\right)\right)\delta\left(j - f\left(x+\Delta x, y+\Delta y\right)\right)\right)}{|\Omega|} \tag{1}$$

Here, the displacement vector $(\delta x, \delta y)$ represented that there is pixel value in position how long is departed from pixel of interest (x,y). Set ω is (x,y) that the position after displacement is not deviated from pixel value. Since the different GLCM is obtained by the different displacement vector, we need to select the displacement vector appropriately. On the other hand, the matrix P as shown in Eq. (2) is represented as the normalized symmetry GLCM.

$$P_{ij} = \frac{V_{ij} + V_{ji}}{2\sum_{i,j=0}^{L-1} V_{ij}} \tag{2}$$

By using Eqs. (1) to (2), the statistical texture features used in this study are shown in Eqs. (3) to (7) of the following.

$$Energy: \quad F_1 = \sum_{i,j=0}^{L-1} \left(P_{ij}\right)^2 \tag{3}$$

$$Entropy: \quad F_2 = -\sum_{i,j=0}^{L-1} P_{ij} \log P_{ij} \tag{4}$$

$$Contrast: \quad F_3 = \sum_{i,j=0}^{L-1} (i-j)^2 P_{ij} \tag{5}$$

$$Correlation: \quad F_4 = \sum_{i,j=0}^{L-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2} \tag{6}$$

$$Homogeneity: \quad F_5 = \sum_{i,j=0}^{L-1} \frac{P_{ij}}{1+(i-j)} \tag{7}$$

Here, μ, σ^2 are represented as shown in Eqs. (8) and (9).

$$\mu = \sum_{i,j=0}^{L-1} i P_{ij} \tag{8}$$

$$\sigma^2 = \sum_{i,j=0}^{L-1} P_{ij} (i-\mu) \tag{9}$$

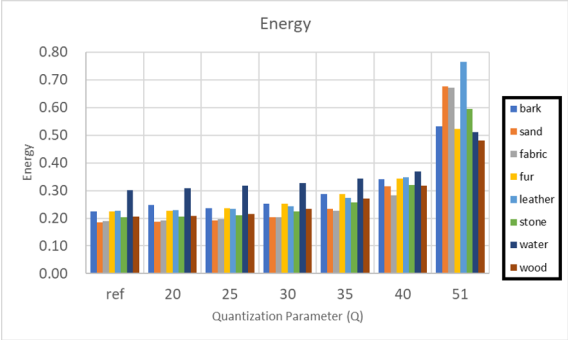

Figure 9. *Result of Exp. (Energy) [2]*

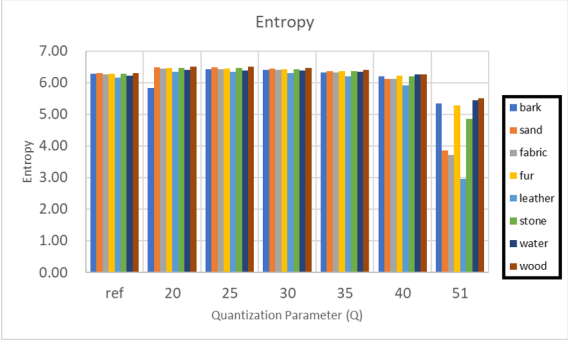

Figure 10. *Result of Exp. (Entropy) [2]*

4. Experimental Results and Discussion

Figs. 9 (Energy), 10 (Entropy), 11 (Contrast), 12 (Correlation), and 13 (Homogeneity) show experimental results by texture features. Here, the vertical axis is each statistical texture features, and then the horizontal axis is Quantization Parameter (Q). Explanatory note is content types of Shitsukan Research Database. On the other hand, in order to compare between texture feature and luminance, Figs. 14 (bark), 15 (sand), 16 (fabric), 17 (fur), 18 (leather), 19 (stone), 20 (water), and 21 (wood) show visualization as average image of heat map by Shitsukan types for luminance database.

4.1. For "Energy"

For "Energy" of Fig. 9, in the case of $Q = 51$, feature scores of "leather," "sand," and "fabric" are seen as raising rapidly. On the other hand, in the case of $Q \leq 40$, feature score of "water" is the highest of all contents, and then those of "sand," "fabric" are before and after 0.20 in the case of $Q \leq 35$. This is tend to low score among contents. Referring the luminance heat map, heat maps of "sand" and "fabric" can be assumed that these related each other because these are included for red region sparsely.

4.2. For "Entropy"

For "Entropy" of Fig. 10, in the case of $Q \leq 40$, it is not seen the difference among contents, and then $6.00 < Entropy < 6.30$ is satisfied. In image contents which design is complicated, decline of "Entropy" is seen clearly. Referring the luminance heat map, we can see that luminance in "sand," "fabric," and "leather" are related mutually.

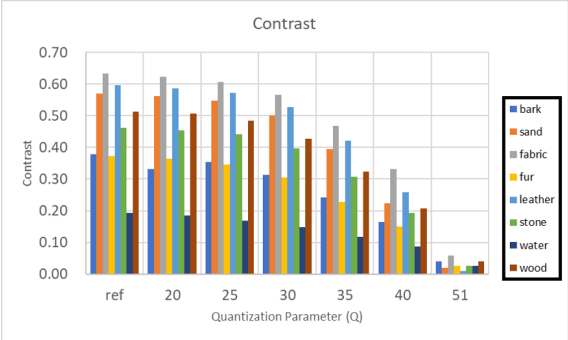

Figure 11. *Result of Exp. (Contrast) [2]*

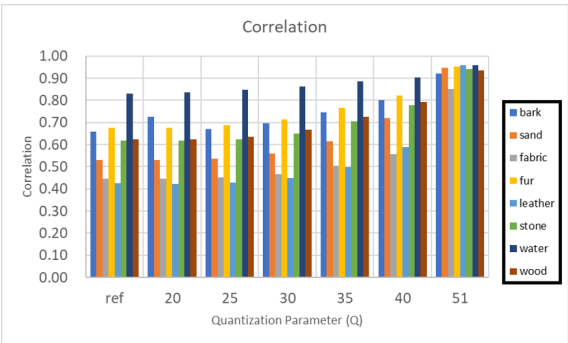

Figure 12. *Result of Exp. (Correlation) [2]*

4.3. For "Contrast"

For "Contrast" of Fig. 11, in the case of $Q = 51$, it is hardly seen for characteristics. For feature score of "water", in the case of $Q \leq 40$, it is less than 0.20 among contents, and then that of "Contrast" is tend to low. Focused on Fig. 7, stripped pattern is often seen, comparing to other contents. This is not high for contrast as pattern. Therefore, we can assume to low contrast subjectively. Referring the luminance heat map, there is many red regions. From this, we can see that higher luminance region in an image is affected to result as stripped pattern.

4.4. For "Correlation"

For "Correlation" of Fig. 12, the higher Q is, the higher correlation is, however, the difference among contents can be seen. Particularly, for "fabric," and "leather", in the case of $Q \leq 35$, "Correlation" is less than 0.5, and then it is not seen for "Correlation" comparing to other contents. On the other hand, for "water", "Correlation" is more than 0.8 in all Q. Therefore, we can judge as correlation. Referring the luminance heat map, we can assume that there is relationship whether the stripped pattern of red and blue regions is equal or not.

4.5. For "Homogeneity"

For "Homogeneity" of Fig. 13, feature score of "water" is more than 0.9 in all Q. This can be seen as tend to high. For other patterns, "Homogeneity" is more than 0.75 in all patterns. Therefore, we can judge that there is homogeneity constantly in all patterns. Referring the luminance heat map, we can assume that there is relationship whether there are bias between red and blue regions or not.

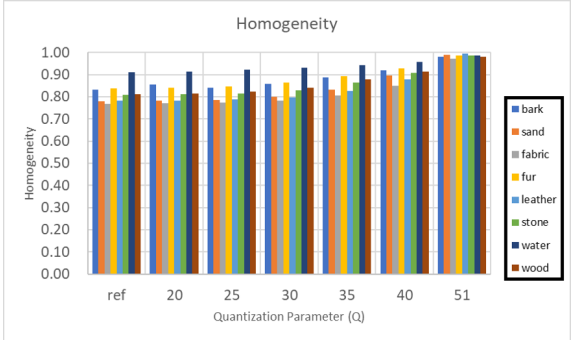

Figure 13. *Result of Exp. (Homogeneity) [2]*

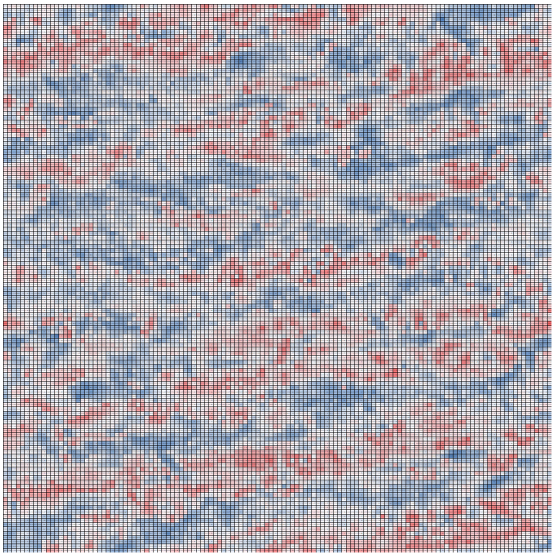

Figure 14. *Lum Heatmap (01_bark)*

5. Conclusion and Future Work

In this paper, first we carried out the texture analysis for generated images encoded and decoded by H.265/HEVC by using the Shitsukan Research Database. Next, we discussed to visualize the luminance characteristics among contents by using luminance heat map. From experimental results, it is enabled to perceive stripped pattern and characteristics among contents which is not clarified for texture analysis and data mining by using heat map.

As our future works, based on novelty and knowledge obtained from this study, we will analyze, quantify, and visualize for Shitsukan or texture in detail.

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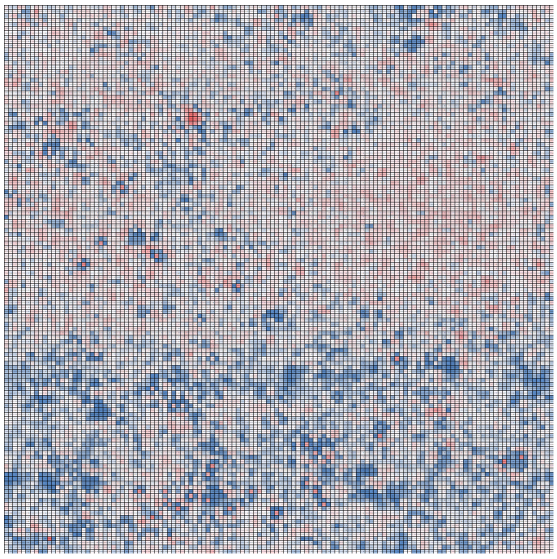

Figure 15. *Lum Heatmap (02_sand)*

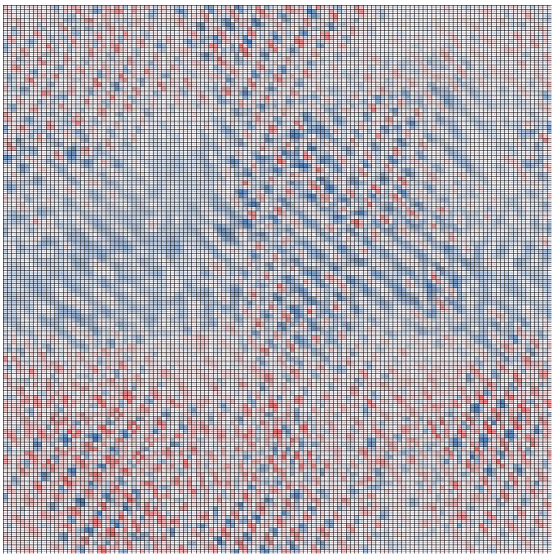

Figure 16. *Lum Heatmap (03_fabric)*

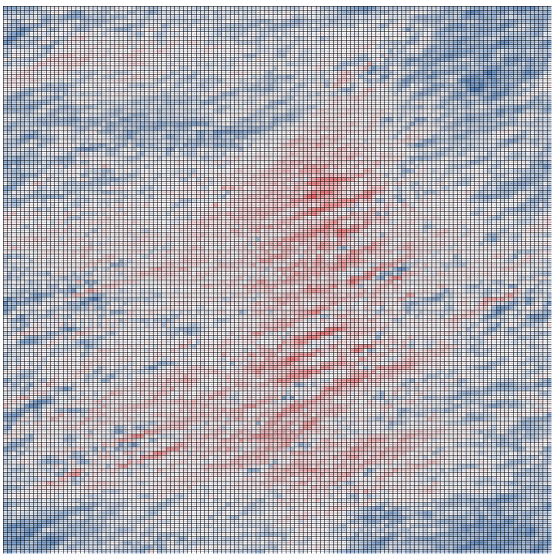

Figure 17. *Lum Heatmap (04_fur)*

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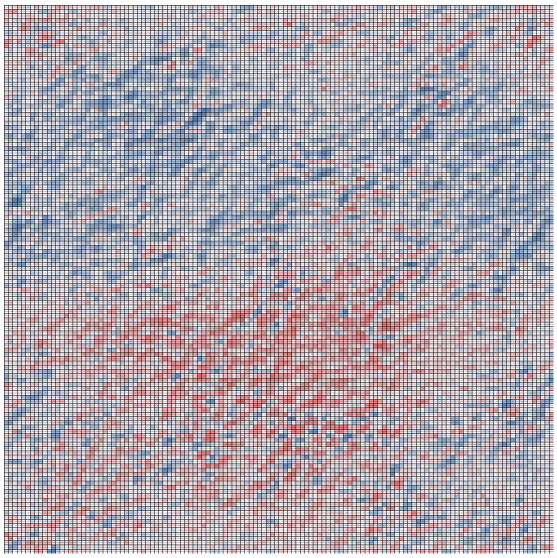

Figure 18. *Lum Heatmap (05_leather)*

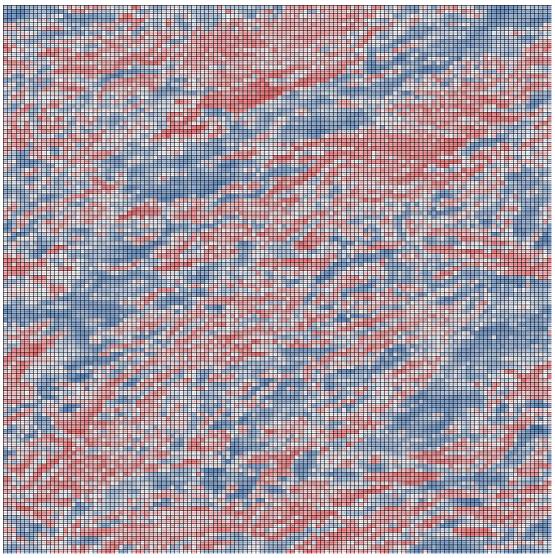

Figure 20. *Lum Heatmap (07_water)*

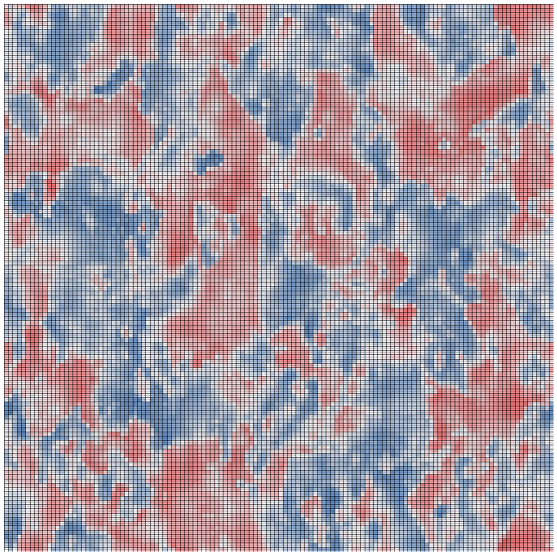

Figure 19. *Lum Heatmap (06_stone)*

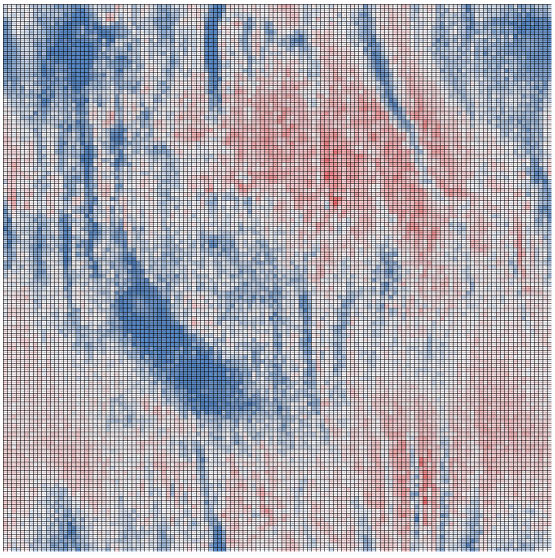

Figure 21. *Lum Heatmap (08_wood)*