Transition of Matière feature of Claude Monet's Paintings Analyzed by Wavelet Transform and Co-occurrence matrix

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Abstract

"Matière" plays an important role in paintings to create an atmosphere to tableaux. We investigated transition of feature of "matière" or texture features of Claude Monet's paintings because he painted many series of paintings in which he used little a bit different brushwork to the same tableau. As a first step to know texture feature of color images of his paintings we analyzed grayscaled images of paintings in seven composition categories by 2-D wavelet transform. Then we calculate an image characteristic amount from the result of wavelet multi-resolution analysis of the painting images to clarify their texture feature quantitatively. We also analyzed images of paintings with co-occurrence matrix and calculate amount of characteristics. As a result, we are able to confirm the changes of the brushwork in the case of the series of the paintings "water lily" from 1899 to 1926. This result indicates that we can use the image characteristic amounts as objective index of texture feature or "matière" of paintings and we can recognize the change of "matière" alter with time in the series of paintings.

Introduction

In the analytical studies of paintings, texture analysis has been used to characterize each painting[1], and also used to indentify artists of each painting[2]. As brushwork of the painters as well as materials they use determine texture of paintings, texture features reflect the characteristics of painters and style of paintings. Transition of texture features derived from texture analysis probably represents change of touch and style with the years.

Claude Monet was a French painter who is famous for founder of impressionist paintings. He left many paintings and there is transition of style in his 86 years life. He painted many series of paintings and these paintings are suited for studying transition of style because they are almost same tableau.

In this study we intend to make it clear if we can detect transition of touch of paintings by the image characteristic amount calculated from the result of wavelet multiresolution analysis or from co-occurrence matrix.

Methods

Images for Analysis

We used painting images of Claude Monet who is very famous French impressionist painter. He worked on series paintings such as Rouen Cathedral, Houses of Parliament and Water Lilies. We focus on the series of Water Lilies because he produced many works of water lilies in his later years. We used Claude Monet's painting images downloaded from official website of Claude Monet exhibit at the Grand Palais in Paris for image analysis. We chose 14 Monet's painting images of water lilies from 1899 to 1926 and cut out the part of typical water lilies on the water 512 x 512 pixels in size from whole painting images

4000 x 590 - 7830 x 1110 pixels in size (Figure 1). All images are transformed into L*a*b* color space and L* channel images were used as garyscale images for image analysis.

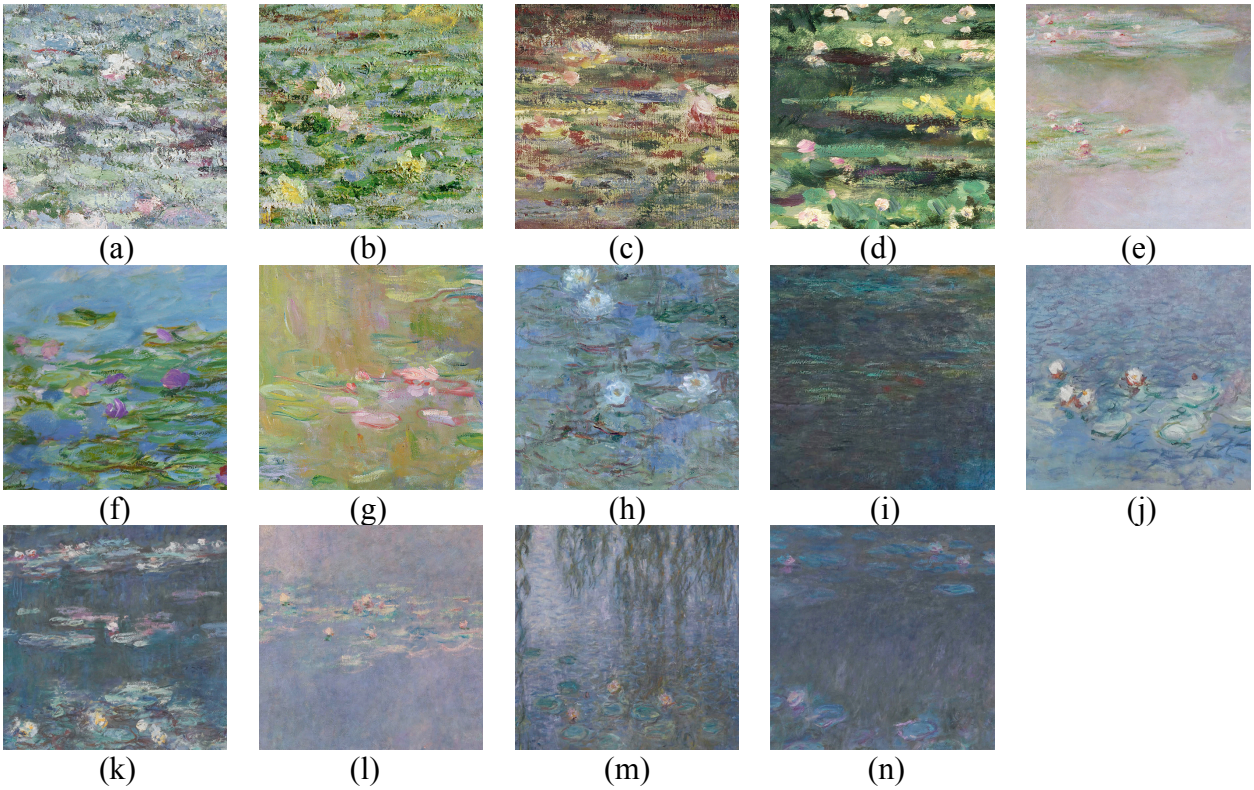

Figure 1: Painting images of water lilies on the water from Claud Monet later years pantings (512x 512 pixels). Images are arranged chronologically. (a) No.102 "Water-Lily Pond, Symphony in Green" (1899), (b) No.103 "Water-Lily Pond" (1899), (c) No.104 "Water-Lily Pond, Symphony in Rose" (1900), (d) "Water-Lilies" (1904), (e) "Water-Lilies" (1907), (f) "Red Water-Lilies" (1908), (g) "The Water-Lilies Pond" (1917), (h) "Water-Lilies" (1916-1919), (i) "Water-Lilies" (1914-1926), (j) "Water-Lilies" (1914-1926), (k) "The Water-Lilies" (1914-1926), (l) "Water-Lilies" (1914-1926), (m) "Water-Lilies" (1914-1926), (n) "Water-Lilies" (1914-1926),

Wavelet Multi-resolution Analysis

We analyzed the images of paintings by wavelet multiresolution analysis using the Harr function as the mother wavelet function to see spectral feature of brightness distribution of paintings. Grayscaled painting images were decomposed into eight subband levels and the data of each subband reflects the feature of different spatial frequency and the directional features of the image.
As an indicator of texture feature we calculate an image characteristic amount *RMS* (Root Mean Square) of wavelet coefficient value of HH components in each subband from the result of 2-D discrete wavelet transform of the painting image.

$$RMS \text{ (Root Mean Square)} \qquad f = \sqrt{\frac{1}{I}\sum_{i=1}^{x}\sum_{j=1}^{y}\{w(i,j)\}^2} \qquad (1)$$

where $w(i, j)$ is a wavelet coefficient value of each components and I is a total number of pixels of each subband. Wavelet coefficient values of each subband of multiresolution analysis indicate contribution of each spatial-frequency component to whole image. So a set of *RMS* from each subband is able to considered as an indicator of granularity of whole image and then also one of important texture features.

Analysis with Co-occurrence Matrix

From co-occurrence matrix of painting image we calculate four image characteristic amounts, "angular second moment", "inverse difference moment", "variance" and "contrast".

angular second moment $$f = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left\{p_\delta(i,j)\right\}^2 \quad (2)$$

inverse difference moment $$f = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\frac{1}{1+(i-j)^2}p_\delta(i,j) \quad (3)$$

variance $$f = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(i-\mu)^2\, p(i,j) \quad (4)$$

contrast $$f = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1}|i-j|^2\, p(i,j) \quad (5)$$

where $p(i,j)$ is (i,j)th entry in a co-occurrence matrix, and n is a dimension of the co-occurrence matrix.

Results and Discussion

Chronological transition of *RMS* values of water lilie paintings

Transition of *RMS* value in each subband is plotted chronologically in Figure 2. Paintings in earlier period (No.102, No. 103, No. 104, No.136 which is painted 1899-1904) indicate relatively high value in smaller number subbbands and low value in larger number subbbands, though No.136 is little a bit unique. This means paintings in earlier period abundant in fine detail and fine detail become poor in the paintings in his later years.

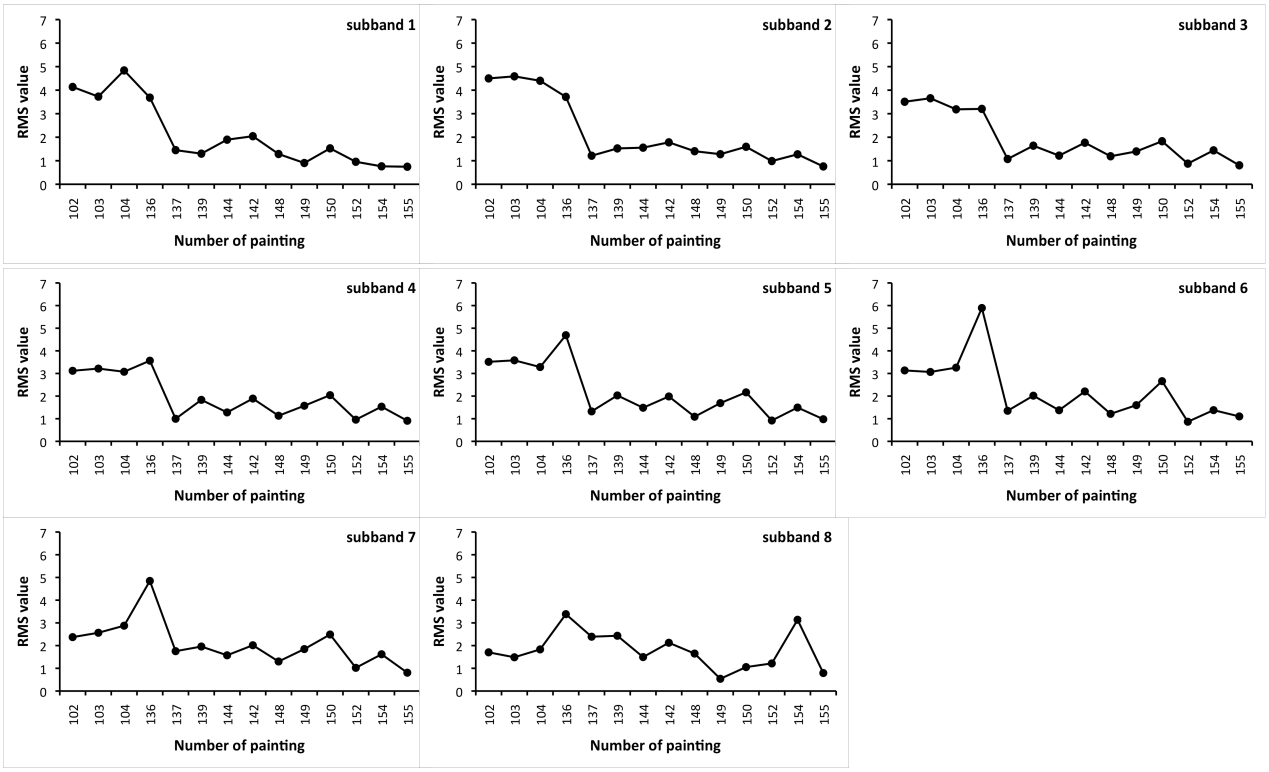

Figure 2: RMS value of 14 paintings in each subband of wavelet multiresolution analysis. Paintings are arrangeed chronologically (No.102: 1899 - No.155: 1914-1926).

Feature amounts of painting image data calculated from co-occurrence matrix

Four feature amounts of painting image data calculated from co-occurrence matrix plotted chronologically are shown in Figure 3. Angular second moment and inverse differential moment are small in the paintings early period and become larger in those later period. As "angular second moment" is an index of uniformity and "inverse difference moment" is an index of flatness in concentration distribution, paintings become uniform flat in later period. In contrast, "variance" and "contrast" are large in the paintings early period and become smaller in those later period. This means variance in brightness become small and contrast become low in later period, because these indexes directory represent variance and contrast of painting images.

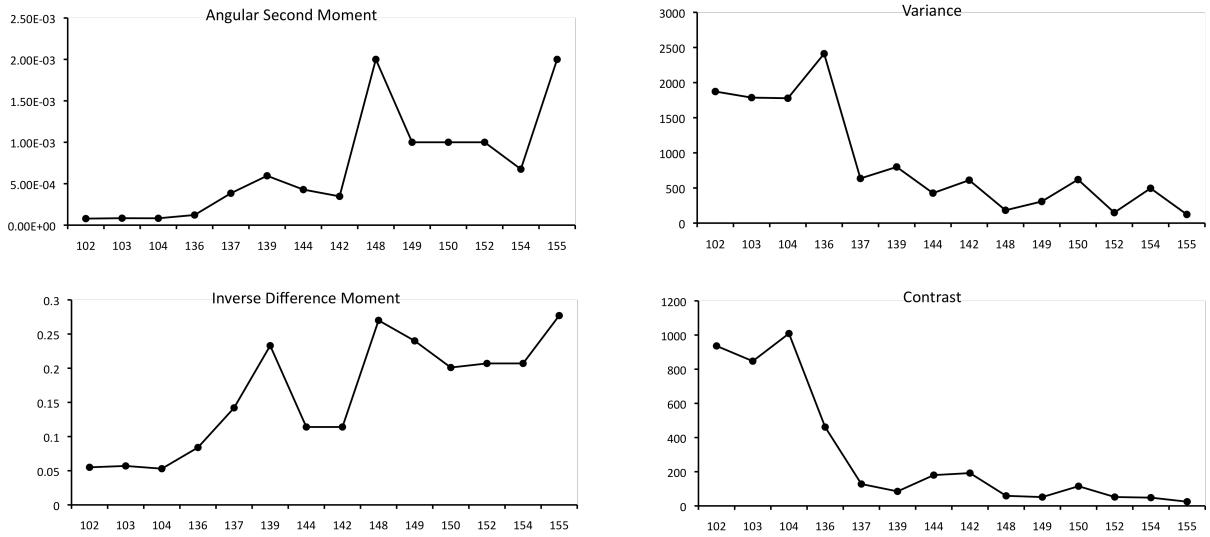

Figure 3: Four feature amounts of painting image data calculated from co-occurrence matrix. Paintings are arrangeed chronologically. Angular second moment:formula (2), inverse difference moment :formula (3), variance: formula (4), contrast: formula (5).

Transition of feature amounts of Monet's paintings and change of his paintings

Feature amounts calculated from wavelet multiresolution analysis and co-occurrence matrix reflect feature of paintings and transition of them in Claude Monet's series of paintings indicate change of touch in his paintings in late years. He was affected by cataract in late years[3] and one of the reason why the transition of touch has been appeared may be this disease. This result indicates that we can use the image characteristic amounts as objective index of texture feature or "matière" of paintings and we can recognize the change of "matière" alter with time in the series of paintings.

References

[1] T. Muroya M. Kobayasi, *A Wave-Length Analysis of Spatial Color Variation in Painting Arts: A comparison of Fourier Transform and Wavelet Transform* (in Japanese), Journal of the Color Science Association of Japan, Vol. 27(SUPPLEMENT), pp.38-39, 2003.

[2] I. Daubechies, *An Introduction to Wavelets for Art Historians*, Proceedings of the International Workshop on Image Processing for Artist Identification - Brushwork in the Paintings of Vincent Van Gogh, pp.141-164, 2007.

[3] Michael F. Marmor, *Ophthalmology and Art: Simulation of Monet's Cataracts and Degas' Retinal Disease*, Arch Ophthalmol., Vol. 124, No. 12, pp.1764-1769, 2006