Universal Image Statistics as a Basis for Esthetic Perception

Michael Koch[1], Joachim Denzler[1], Christoph Redies[2]

[1] Chair for Computer Vision, Friedrich Schiller University of Jena
07743, Jena, Ernst-Abbe-Platz 2, Germany
{koch,denzler}@informatik.uni-jena.de
[2] Chair for Anatomy 1, Friedrich Schiller University of Jena
07743, Jena, Teichgraben 7, Germany
redies@mti.uni-jena.de

In the last decades many neuroscientists have started to investigate the perception of nature and art by the human visual system. Natural scenes lead to an esthetically pleasing perception, therefore scientists have begun to research the reasons to understand the processing principles of the human visual system.

The ultimate goal of our research is to find properties in images that are related to an esthetically pleasing perception. Thus, we investigated different image categories (art, natural scenes, household objects, manmade illustrations, faces and Mangas) and continue earlier approaches on the analysis of the power spectrum of images [1,2]. While it is well known that complex natural scenes show an unique property, a roughly $\frac{1}{f^2}$ power spectrum [3], which is related to so called fractal-like properties of such scenes, we reported about similar behaviour of visual art of different styles and epoches in our previous publication [1].

In this work, we started to analyze the power spectrum in a more specific manner. Instead of measuring the slope of the power spectrum over a certain frequency band, we computed the slope not for the whole power spectrum, but for a certain sector in the 2d power spectrum which is illustrated in Fig.1. We

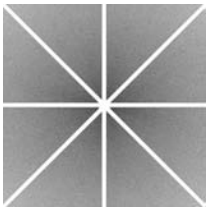


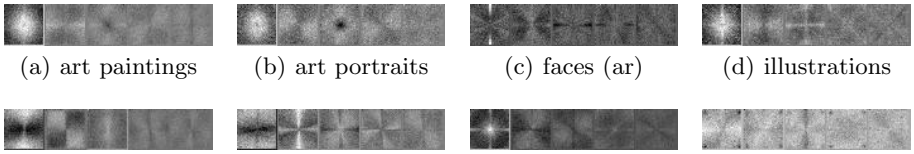
Fig. 1. example 2d power spectrum demonstrating the definition of sectors, outlined by separating lines

figured out that there are differences of the slopes in different sectors. While the slope in visual art seems to be constant over most of the sectors, natural scenes show more variation in the slope for an individual image. Therefore, we calculated the standard deviation of the sector slopes of the 2d power spectrum. This measure is close to zero if the 2d power spectrum is isotropic. Table 1 shows relatively low values (high isotropy) for the categories art portraits, art paintings, plants and Mangas. Especially natural scenes have high values (low

Dagstuhl Event Proceedings 08422
Computer Vision in Camera Networks for Analyzing Complex Dynamic Natural Scenes
http://drops.dagstuhl.de/opus/volltexte/2009/1868

isotropy). But the variance of these values is very high in comparison to the low differences of means.

Furthermore, we performed principal component analysis (PCA) to determine common and different properties of the composition of the 2d power spectrum images from different categories. The first five principal components of the different categories are illustrated in Fig.2. Plants, art portraits, art paintings and manmade illustrations have an isotropic principal component. This is only a hint that the images of these categories are isotropic, because those components can be added or subtracted in the linear combination which creates the 2d power spectrum of a specific image. Therefore, the 2d power spectrum of sample images of these categories need not to be isotropic. But in combination with the results of Table 1 the categories plants, art portraits and art paintings show more isotropic characteristics in the 2d power spectrum than other image categories. Moreover plants do not have the fractal-like property, as shown by Redies et al. [1].



(a) art paintings (b) art portraits (c) faces (ar) (d) illustrations

(e) natural scenes (f) objects (g) plants (h) Mangas

Fig. 2. First five PCA components of different categories

category	**mean**	**standard deviation**
art paintings	0.13	0.07
art portraits	0.15	0.06
faces(AR)	0.21	0.04
faces(Yale)	0.19	0.05
illustrations	0.19	0.10
natural scenes	0.26	0.12
household objects	0.17	0.07
plants	0.14	0.09
Mangas	0.14	0.06

Table 1. Mean and standard deviation of the isotropic measure for every image category

References

1. Redies, C., Hasenstein, J., Denzler, J.: Fractal-like image statistics in visual art: similarity to natural scenes. Spatial Vision **21** (2007) 97 – 117
2. Redies, C., Hnisch, J., Blickhan, M., Denzler, J.: Artists portray human faces with the fourier statistics of complex natural scenes. Network: Computation in Neural Systems **18** (2007) 235–248
3. Ruderman, D.L.: The statistics of natural images. Network: Computation in Neural Systems **5** (1994) 517–548