Complexity perception of texture images

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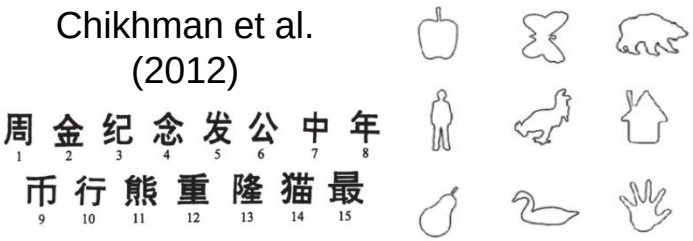
Image complexity

A unique definition of image complexity does not exist: it strongly depends on the field of application.

Chikhman et al. (2012)

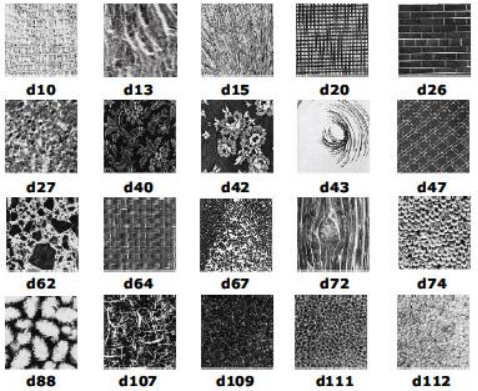


Purchase et al. (2012)

Guo et al. (2013)

Cavalcante et al. (2014)

Ciocca et al. (2015)



Guo et al. (2012)

Aim of this study

Aim of this work is to investigate the complexity perception of real world texture images:

- We set up an experiment and collect subjective data of complexity perception.
- We correlate the experimental data with different image features based on spatial, frequency and color properties.

Stimuli

One sample for each of the 54 classes in the VisTex data set.

VisTex dataset – MIT Media Lab
http://vismod.media.mit.edu/vismod/imagery/VisionTexture

Subjective Experiment

- Images individually shown in random order.
- Observers can look at the stimuli for an unlimited time.

- Complexity scores reported by dragging a slider on the continuous scale in [0-100].

- Observers are asked to verbally describe the characteristics of textures that affect their evaluation of visual complexity perception.

- 17 observers

web-interface.

Processing of subjective data

1. The raw scores r_{ij} for the $i-th$ subject and the $j-th$ image are converted into Z-scores:

$$z_{ij} = \frac{r_{ij} - \bar{r}_i}{\sigma_i}$$

2. The outlier scores are removed: outside an interval of width two standard deviations about the average score for that image.

3. The Mean Scores are evaluated averaging the Z-scores

Objective measures

- M1 CONTRAST
- M2 CORRELATION
- M3 ENERGY
- M4 HOMOGENEITY

} derived from the Grey Level Co-occurrence Matrix

- M5 FREQUENCY FACTOR
- M6 EDGE DENSITY
- M7 COMPRESSION RATIO
- M8 NUMBER OF REGIONS

- M9 COLORFULLNESS [1]
- M10 NUMBER OF COLORS [2]
- M11 COLOR HARMONY [2]

} meaningful only for color images

- M12 FEATURE CONGESTION
- M13 SUBBAND ENTROPY

} visual clutter measures by Rosenholtz et al. [3]

[1] D.Hasler and S.E. Susstrunk. Measuring colorfulness in natural images. Electronic Imaging, p87-95, 2003.
[2] M. Artese, G.Ciocca, and I. Gagliardi. Good 50x70 Project: A portal for Cultural And Social Campaigns. IS&T Archiving 2014 Conference, Final Program and Proceedings, p. 213-218, 2014
[3] R. Rosenholtz, Y. Li and L. Nakano. Measuring visual clutter. Journal of Vision 7, p. 17, 2007.

Correlating subjective/objective data

To evaluate the ability of an objective measure $\{x_j\}$ to predict the Mean Scores, a logistic regression function is used:

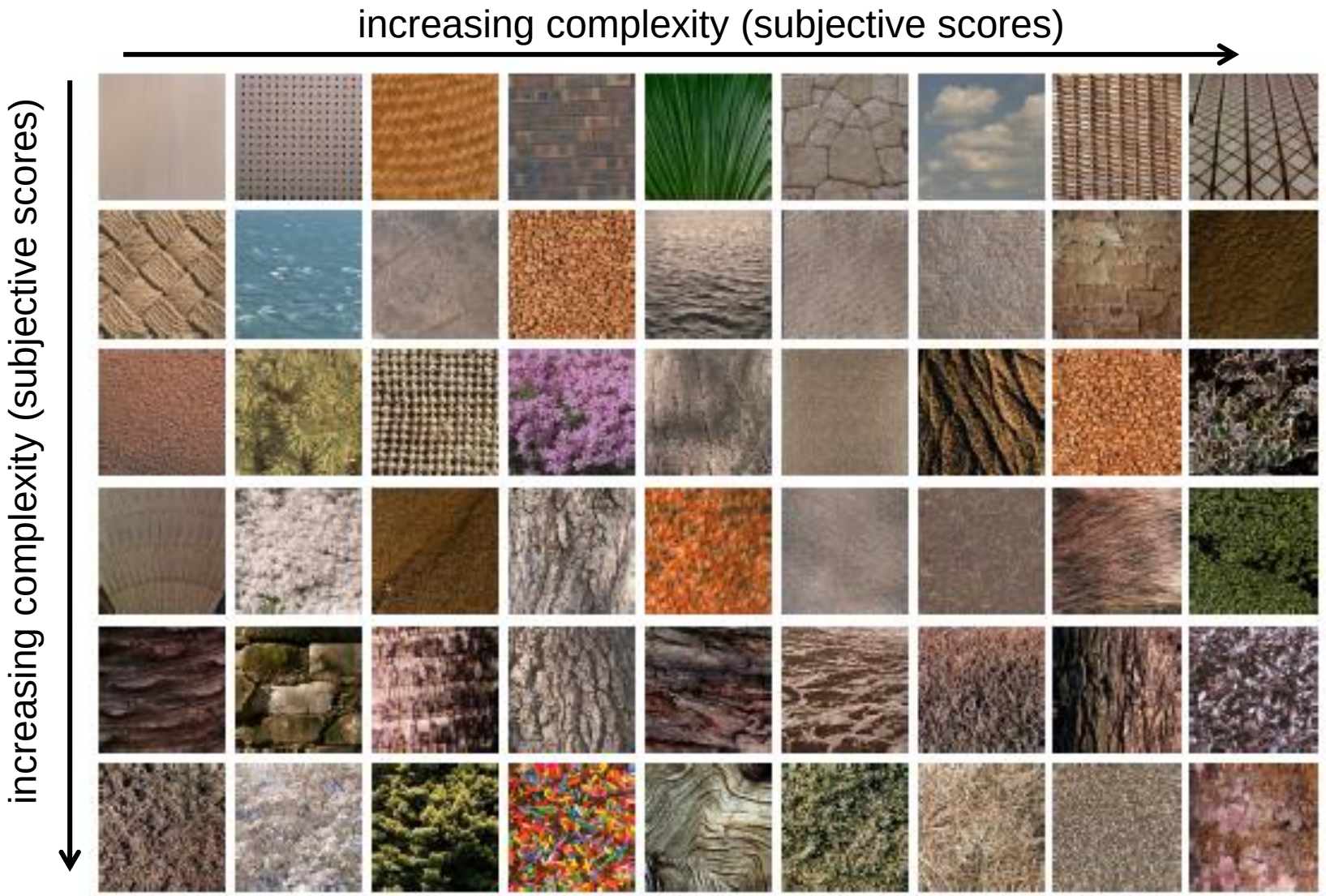
$$f(x_j) = \frac{\alpha}{1 + e^{\beta(x_j - \gamma)}} + \delta$$

where the parameters are chosen to minimize the mean square error between the Mean Scores and the predicted values $f(x_j)$.

We evaluate the correlation using the Linear Pearson Correlation Coefficient (PCC)

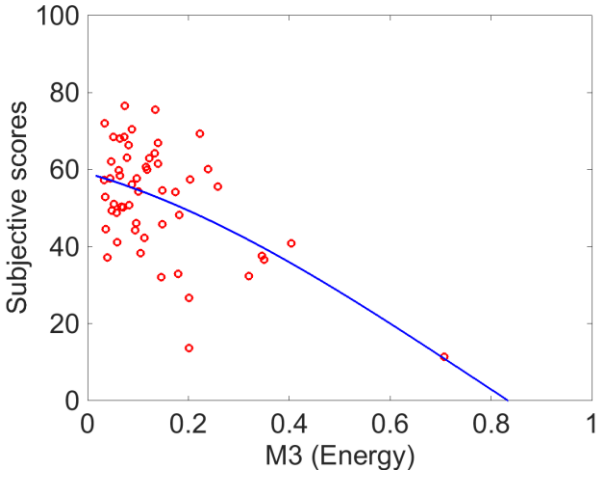
Experimental results

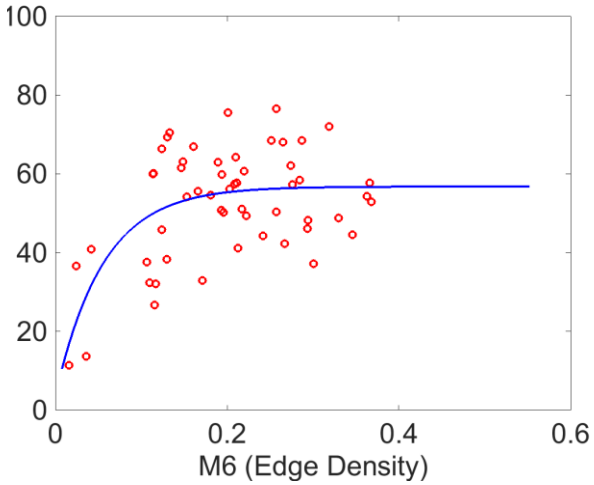
- Images with regular pattern and symmetries judged as less complex
- Images with more details and less ordered judged as more complex

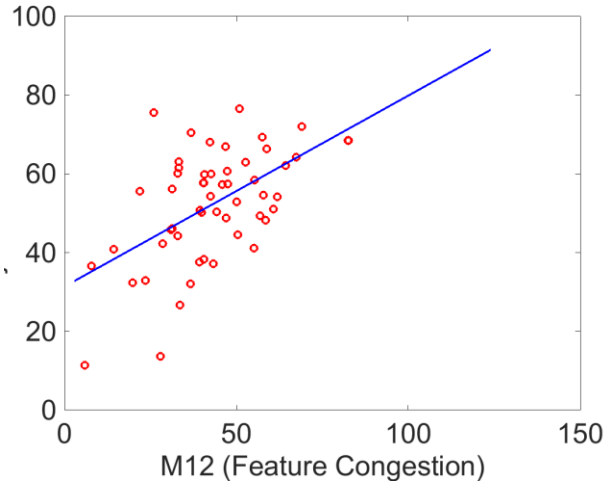


Correlation results

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
PCC	0.43	-	**0.53**	0.42	0.35	**0.58**	0.50	0.47	0.24	0.44	-	**0.55**	0.44







M1=contrast, M2=correlation, M3=energy, M4=homogeneity,
M5=freq. factor, M6=edge density, M7=compression ratio, M8=# regions,
M9=colorfullness, M10=# colors, M11=color harmony,
M12=feature congestion, M13=subband energy

Summary of verbal descriptions

Criteria	Frequency
Regularity	60%
Understandability	47%
Edge density	33%
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In accordance with Guo et al.' (2011) results:

- The major characteristics of textures that affect human visual complexity perception are regularity, understandability, density, and directionality.
- Psychophysical experiment on 20 texture images (Brodatz dataset), 30 observers.

X. Guo, C. Asano, A. Asano and T. Kurita. Visual complexity perception and texture image characteristics. In IEEE International Conference on Biometrics and Kansei Engineering, 260-265, 2011.

Analysis of the results

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- None of the 13 metrics is able to describe the criteria “understandability” and “familiarity”: low correlations found for the single metrics

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Conclusions

- We have identified four characteristics that influence the complexity perception of real world texture images:
  - Regularity
  - Understandability
  - Edge density
  - Familiarity
- From the 13 candidate complexity measures, we found that the three of them with highest correlations are in accordance with the verbal descriptions collected from the questionnaires.
- Work in progress:
  - Increasing the number of observers
  - Combination of single measures: is it able to better describe the experimental data?

V. Chikhman, V. Bondarko, M. Danilova, A. Goluzina and Y. Shelepin. Complexity of images: Experimental and computational estimates compared. Perception 41, 631-647, 2012.

H. Purchase, E. Freeman and J. Hamer. Predicting visual complexity. In Proceedings of the 3rd International Conference on Appearance, 62-65, 2012.

X. Guo, T. Kurita, C. Asano and A. Asano. Visual complexity assessment of painting images, In Image Processing ICIP 2013.

Cavalcante, A. Mansouri, L. Kacha, A. Barros, Y. Takeuchi, N. Matsumoto and N. Ohnishi. Measuring streetscape complexity based on statistics of local contrast and spatial frequency, PloS one 9, 2014.

G. Ciocca, S. Corchs, F. Gasparini, E. Bricolo and R. Tebano. Does color in infuence image complexity perception, In Computational Color Imaging, Lecture Notes in Computer Science 9016, pp. 139-148, 2015.