

Texture Metric

**CTIA 2009
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CPIQ Texture Definition

- Mid-to-high spatial frequency image content of low contrast such as foliage, grass, and fabrics



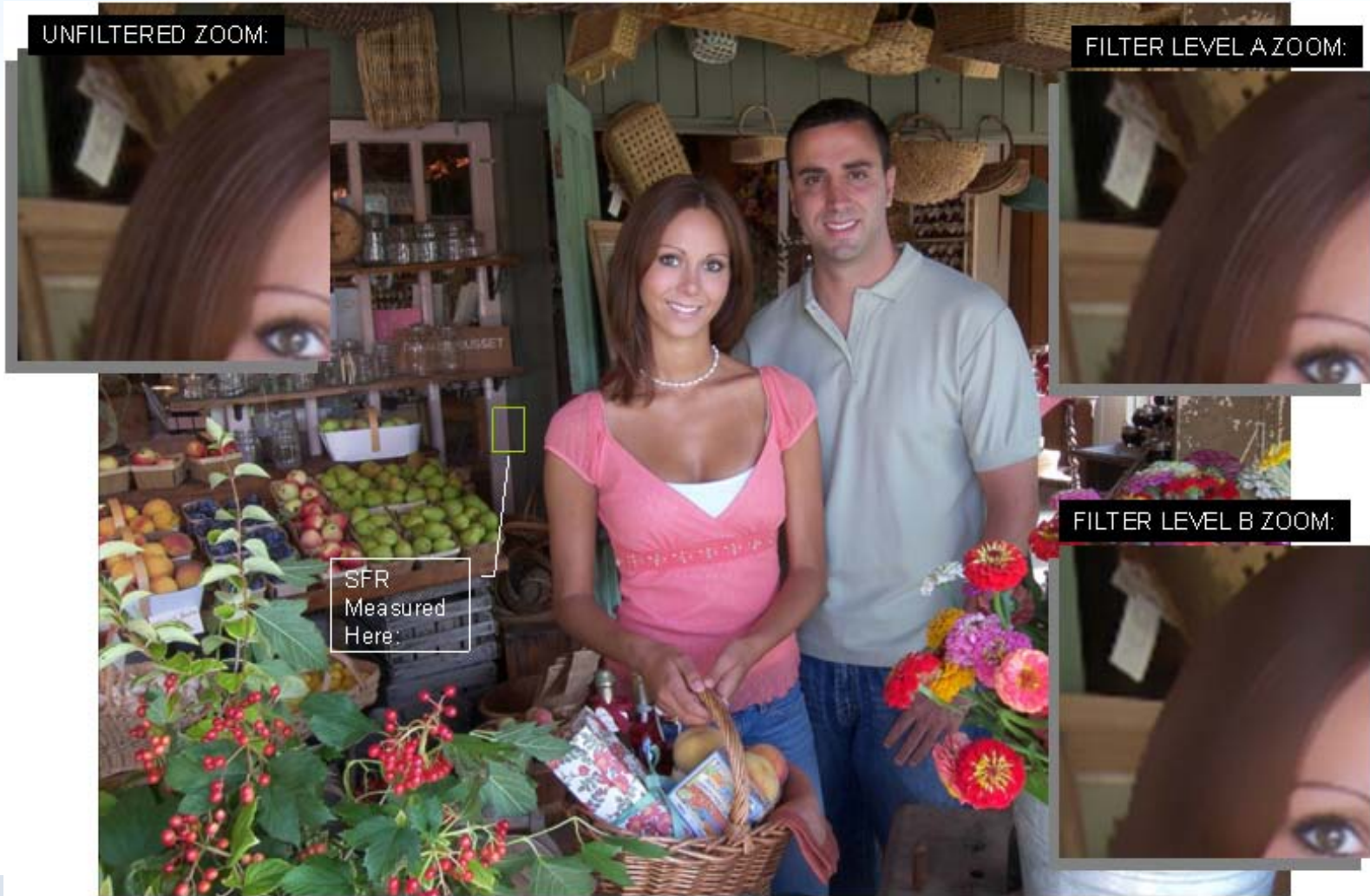
Need for Noise Cleaning Filters

- Sensors in camera phones have image quality limitations due to optics, size, and cost constraints
- As sensors increase in megapixels, physical size of pixels often decreases
 - Challenges at low light capture conditions
 - Tends to increase image noise
- Noise cleaning filters minimize noise in low-frequency regions, but leave high-frequency edges intact
- As strength of noise cleaning filter increases, texture diminishes in image

Traditional Sharpness Metric

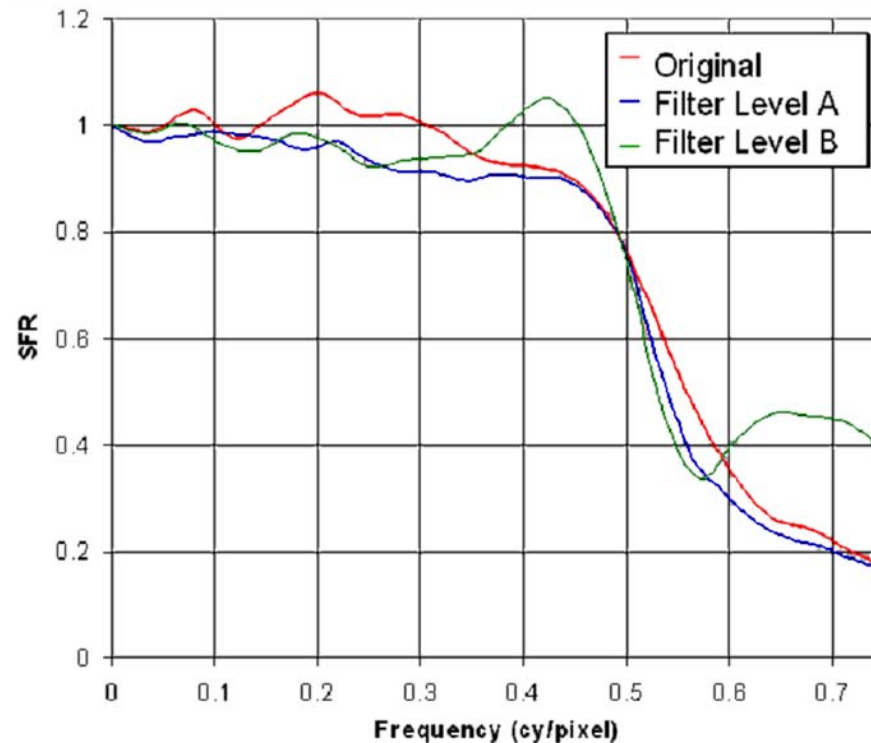
- Traditional spatial frequency response (SFR) metric characterizes a photographic system's response to edge sharpness
- Does not account for mid-to-high frequency content different from extended edge
 - SFR ignores texture quality
 - Reproduction of objects such as terrycloth and foliage is not incorporated in traditional metric
- Degrading effects of nonlinear noise cleaning filters can potentially escape SFR metric

Example of Two Filter Levels Applied to Scene



Spatial Frequency Response (SFR) Results

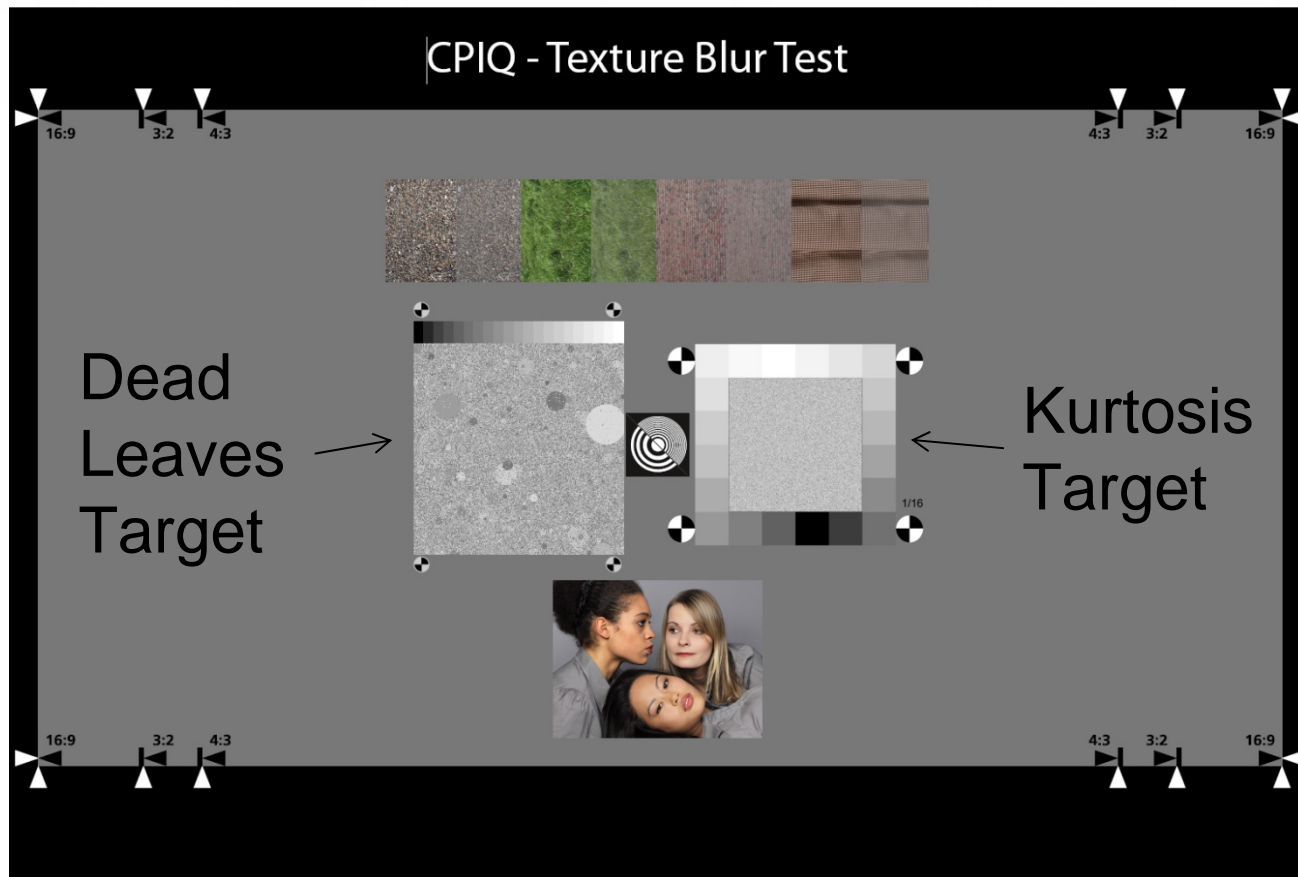
- SFR results do not identify texture differences



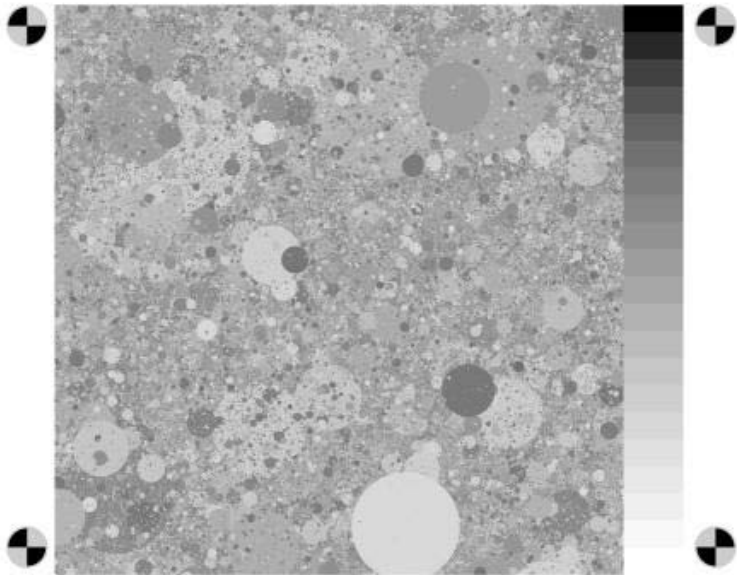
CPIQ Texture Metric

- Texture metrics are needed for the imaging industry
- CPIQ is developing a standardized texture metric comprised of complementary methods
 - Kurtosis objective metric
 - Dead leaves objective metric

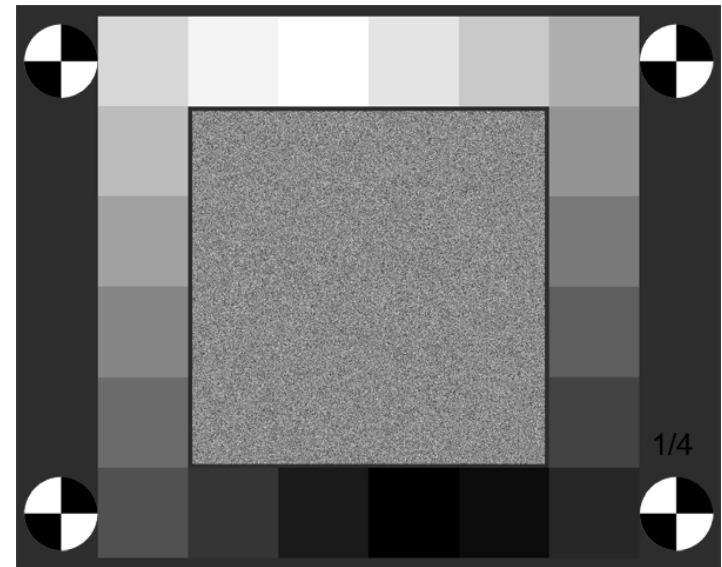
Current Version of Texture Target



Target Components Under Development



Dead Leaves Target



Kurtosis Target

Kurtosis Objective Metric

- Gaussian white noise target with noise variance of 1/32
- Fourth standardized moment
- Calculated from the second and fourth moments of the distribution of the histogram of the image noise:

$$Kurtosis = \frac{m_4}{m_2^2} - 3 = \frac{m_4}{\sigma^4} - 3 = \left(\frac{1}{n} \sum_{i=1}^n \left(\frac{x_i - \mu}{\sigma} \right)^4 \right) - 3$$

where m_2 and m_4 are the second and fourth moments, respectively, σ is the standard deviation, and μ is the mean

- Kurtosis increases as noise becomes non-Gaussian; lower kurtosis is better quality

Dead Leaves MTF Objective Metric

- Target based on dead leaves model of mathematical morphology
 - Randomly sized discs occluding each other in the plane
 - Low contrast in order to pinpoint texture behavior
- Power spectrum of filtered dead leaves target is compared to power spectrum of unfiltered target
- Resultant spectrum is multiplied by a contrast sensitivity function (CSF) to incorporate the visual response of the human eye
- Final result is one number where higher is better quality

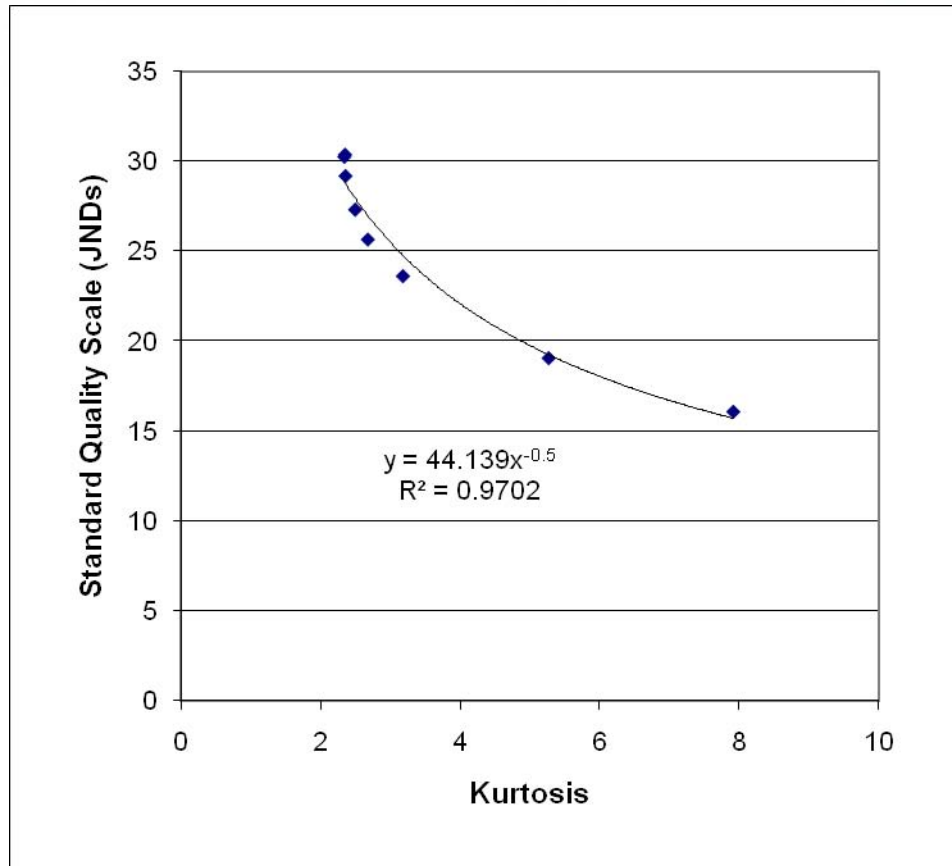
Dual Metric Approach

- Each complementary metric has potential to overestimate texture quality, *e.g.*,
 - Kurtosis indicates good texture quality if camera phone generates very blurry images
 - Dead leaves indicates good texture quality if camera phone image processing and compression generate texture where it was not present in the original scene

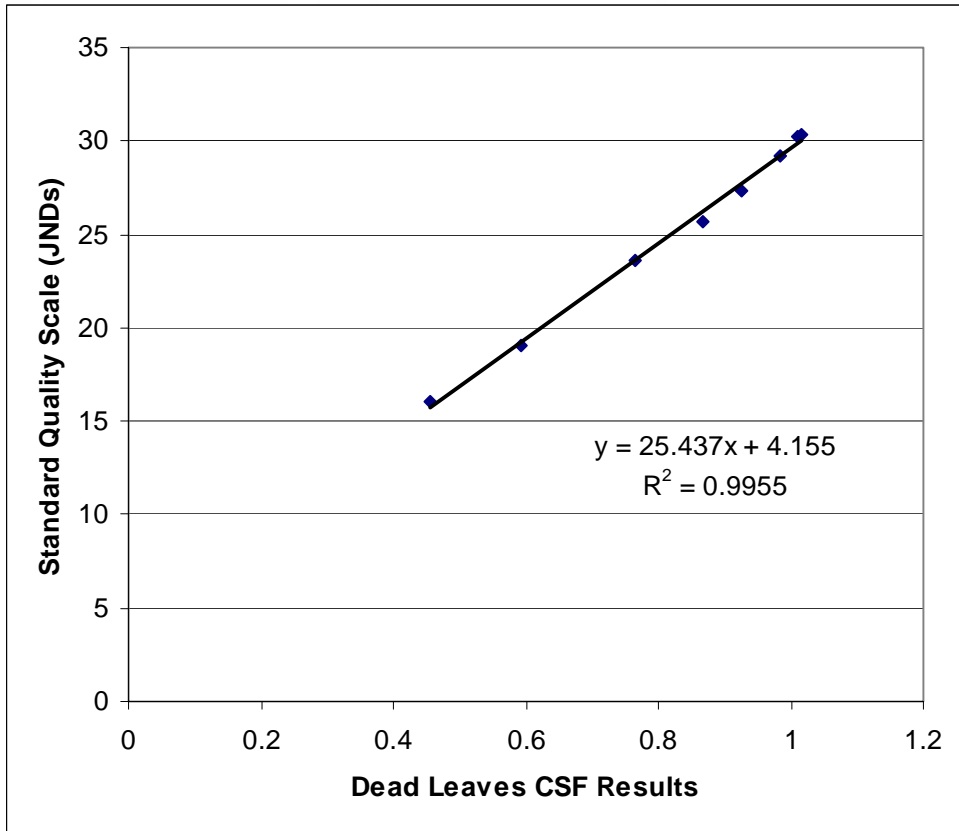
Subjective vs. Objective Correlation

- Using a softcopy quality ruler method based on ISO 20462 Part 3 method, three companies evaluated texture
 - Eight levels of texture detail
 - Ten different photographic scenes
- Subjective results have been correlated to the objective metrics

Kurtosis Correlation



Dead Leaves Correlation



Conclusions

- The CPIQ initiative of I3A is developing a standardized texture metric to be completed in 2009
- Texture perception can be modeled with an objective metric
- High correlation between objective and subjective data for texture metric
 - Kurtosis method had correlation of 0.97 (power fit)
 - Dead leaves method had correlation of 0.99 (linear regression fit)

Published Papers in 2009

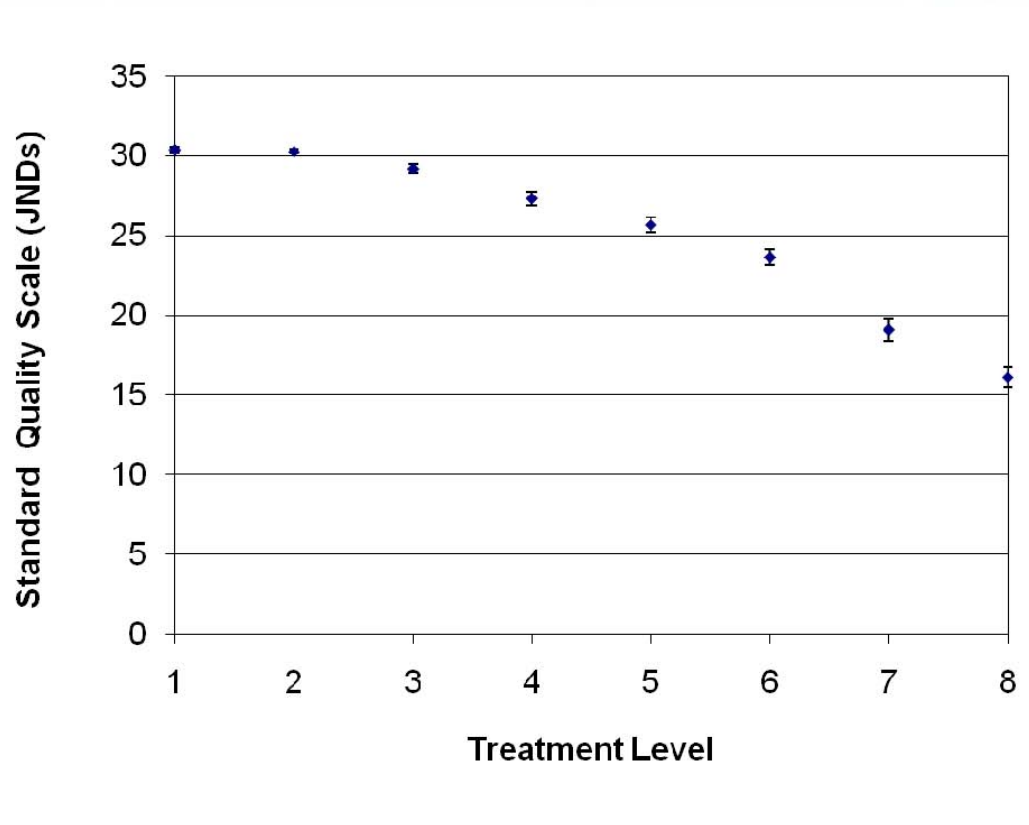
- Interaction of image noise, spatial resolution, and texture preservation in digital image processing
 - Uwe Artmann and Dietmar Wueller
- Measuring texture sharpness of a digital camera
 - Frédéric Cao, Frédéric Guichard, and Hervé Hornung
- Correlating objective and subjective evaluation of texture appearance with applications to camera phone imaging
 - Jonathan B. Phillips, Stephen M. Coppola, Elaine W. Jin, Ying Chen, James H. Clark, and Timothy A. Mauer



Ten Scenes for Subjective Methods



Overall Subjective Test Results



Scene Dependency of Subjective Results

