Finding "good" features for natural scene classification

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Natural scene categorization by humans

- Readily assign basic-level categories (Tversky & Hemenway, 1983)
- Rapid and efficient (Thorpe et al., 1996)
- Needs little visual attention (Fei-Fei et al., 2002)
- Require localized spectral information (Loschky et al., 2007)

Natural scene categorization by computers

- Power spectrum (magnitude of spatial frequencies; Oliva & Torralba, 2001)
- Bag of words (local texture descriptors; Fei-Fei & Perona, 2006)
- Spatial pyramid to vary localization (Lazebnik et al., 2006)

An integrative approach for feature analysis

Dataset

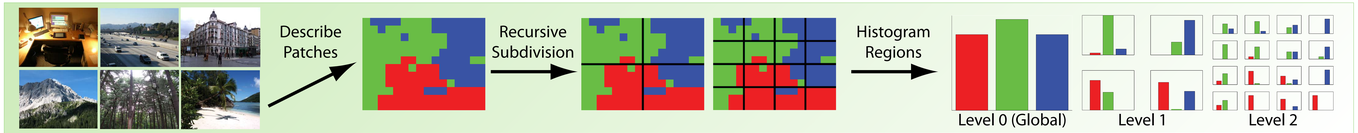
Six natural categories: beaches, cities, forests, highways, mountains, and offices.

100 images per category; 50 rated as "good", 50 rated as "bad" (see Torralbo et al., poster 33.303).

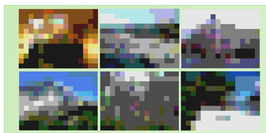
Method

Hold patch size (16 x 16 pixels), grid spacing (8 pixels), and classifier (Linear SVM) constant.

Measure the following for each feature:
- The degree of localization resulting in the highest classification rate
- The correlation between classification errors and human behavior
- The difference between good and bad category exemplars

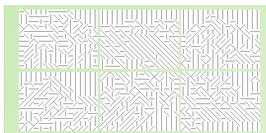


Color

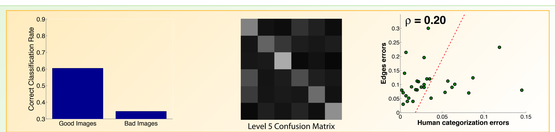


- Average color in each patch
- 5 histogram bins per color channel (R, G, and B) for 125 bins in total

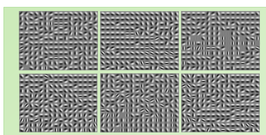
Edges



- Detect Canny edges in different orientations
- The gradient was calculated in four directions
- Non-maximum suppression and hysteresis thresholding traced good edges

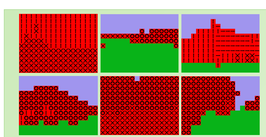


Gabor filters

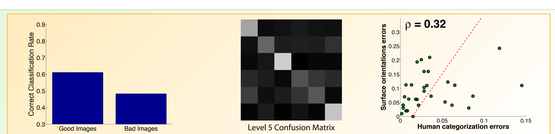


- This feature captures the dominant orientation and frequency of each patch
- Gabor filters at 4 scales and 8 orientations
- Find the filter that exhibited the strongest response when centered over the patch

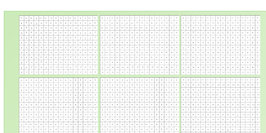
Surface orientations



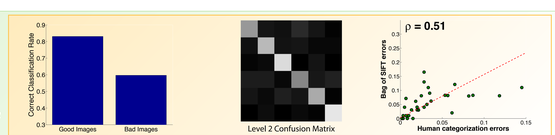
- Reconstructed using Hoiem, et al. (2005)
- Histogrammed into seven bins: ground plane, sky, and vertical surfaces that are one of: solid, porous, frontal, 45 degrees out-of-plane, or 135 degrees out-of-plane
- Surface orientations capture 3D scene layout



Bag of SIFT

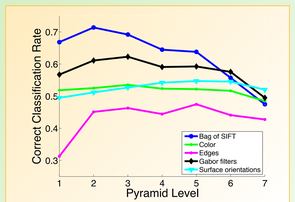


- Same approach taken by Lazebnik, et al., but restricted to a single level of the pyramid
- 200 word dictionary created by clustering all patch descriptors
- SIFT features exhibit invariance to rotation and scale, similar to neurons in primate IT (Lowe, 2004)



Feature localization

- All features benefit from some localization
- No improvement for any feature beyond level 6



Good and bad images

- Classification is consistently worse for images rated as "bad"

Correlating error patterns

- One way to compare human and computer scene classification
- Features with high classification rates can show different error patterns than humans (e.g., Gabor filters)

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