Crisp Boundary Detection Using Pointwise Mutual Information (PMI)

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Boundary detection

Goal:

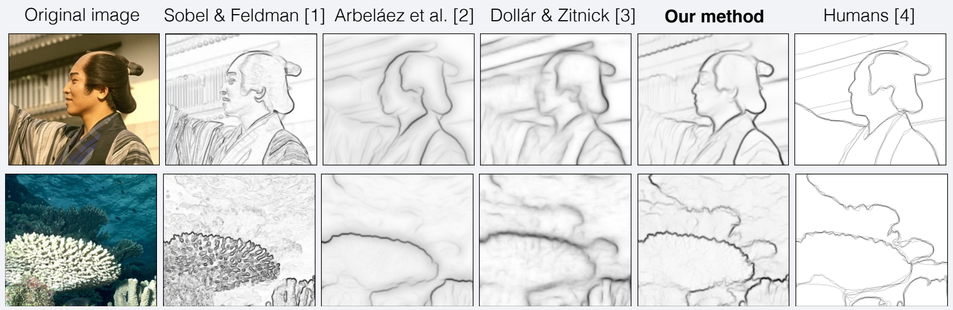
Find boundaries between image regions in a way that mimics human performance.

Boundaries labeled by humans [4]

Previous work
- Non-adaptive rules
- Complex features

Our work
- Image-adapting rules
- Simple features

How do you find a boundary?



Pixels within the same object have higher statistical association than pixels belonging to different objects.

Simple

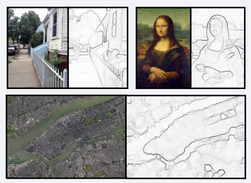
Unsupervised

High quality results

Code available

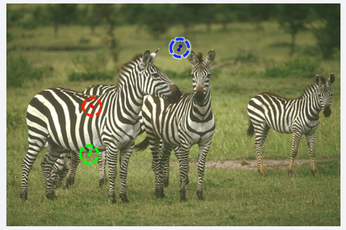
```
boundaries = findBoundaries(I);
```

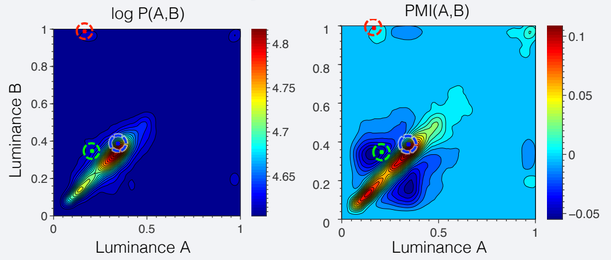
mit.edu/pmi-boundaries



[1] Sobel, I. and Feldman, G., "A 3x3 Isotropic Gradient Operator for Image Processing", presented at the Stanford Artificial Intelligence Project in 1968.
[2] Arbeláez, P., Maire, M., Fowlkes, C., Malik, J.: Contour detection and hierarchical image segmentation. IEEE Trans. PAMI, 2011.
[3] Dollár, P., Zitnick, C.: Structured Forests for Fast Edge Detection. ICCV, 2013.
[4] Martin, D., Fowlkes, C., and Malik, J., "Learning to Detect Natural Image Boundaries Using Local Brightness, Color and Texture Cues," IEEE Trans. PAMI, 2004.

Pointwise mutual information reveals object structure



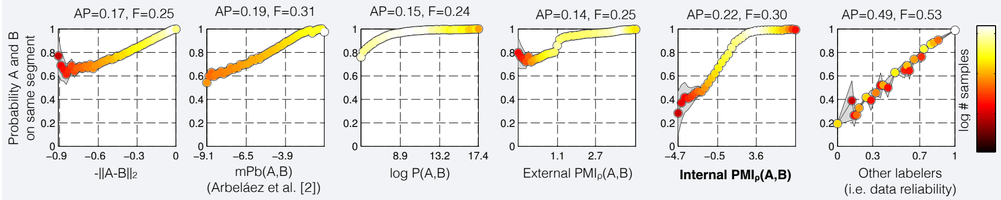


Above, black-next-to-white occurs over and over again. This pattern shows up in the image's statistics as a *suspicious coincidence* — these colors must be part of the same object!

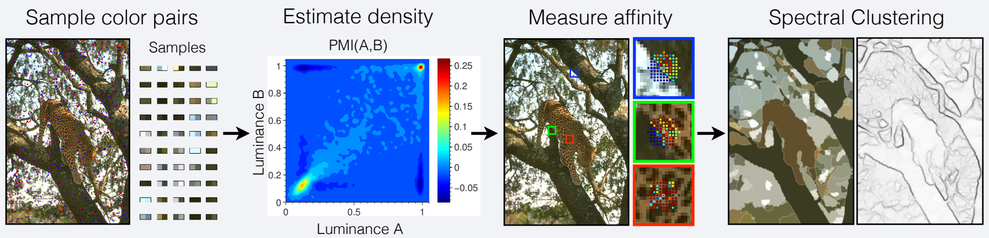
We measure how often each color A occurs next to each color B *within the image*.

$$\mathrm{PMI}_\rho(A,B) = \log \frac{P(A,B)^\rho}{P(A)P(B)}$$

PMI is predictive of whether or not two pixels lie on the same object:

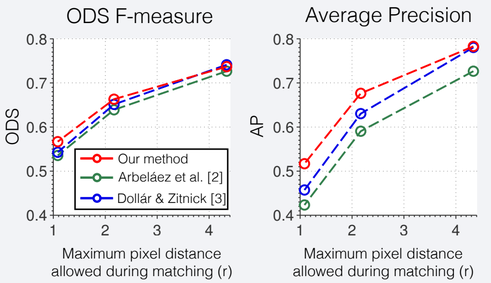


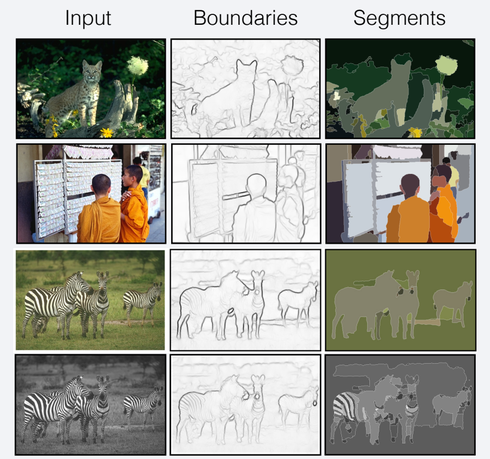
From PMI to segments and boundaries



1. Get affinity between pixel pairs using PMI — our contribution
2. Apply affinity-based boundary detection — standard techniques (Arbeláez et al. [2])

Results





Take home message

PMI is a powerful affinity measure for boundary detection and segmentation. It is unsupervised and relies entirely on simple internal image statistics.