Object-Specific Figure-Ground Segregation

Stella X. Yu and *Jianbo Shi*, Carnegie Mellon University

Basic Idea

Traditional approaches:

1. Image Segmentation $\Longrightarrow$ Object Recognition

   (Marr, 82; Witkin & Tenenbaum, 83; ...)

2. Object Recognition $\Longrightarrow$ Image Segmentation

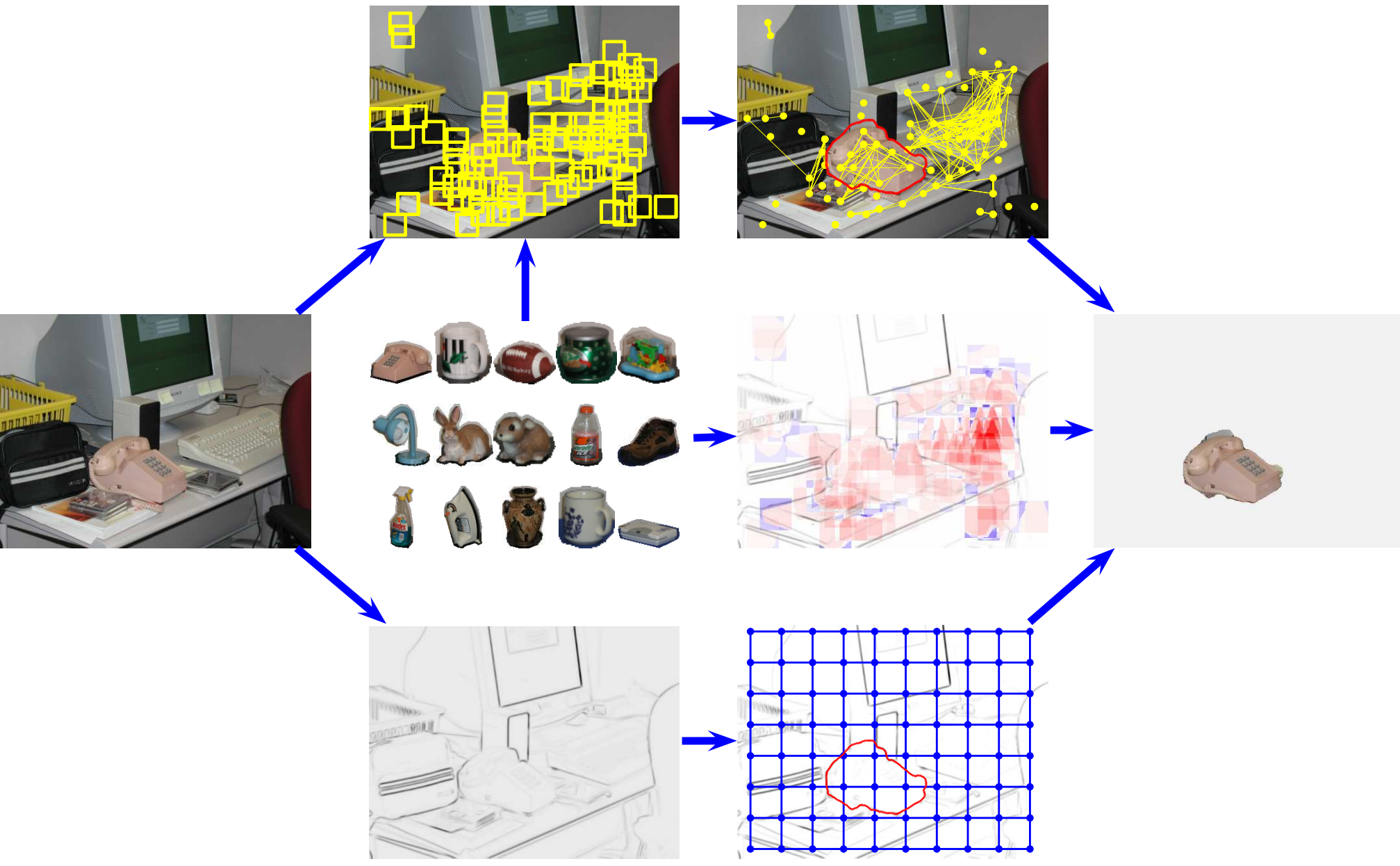
   (Yuille et al, 89; Blake & Isard, 98; Xu et al, 2000; Borenstein & Ullman, 2002)

Our approach:

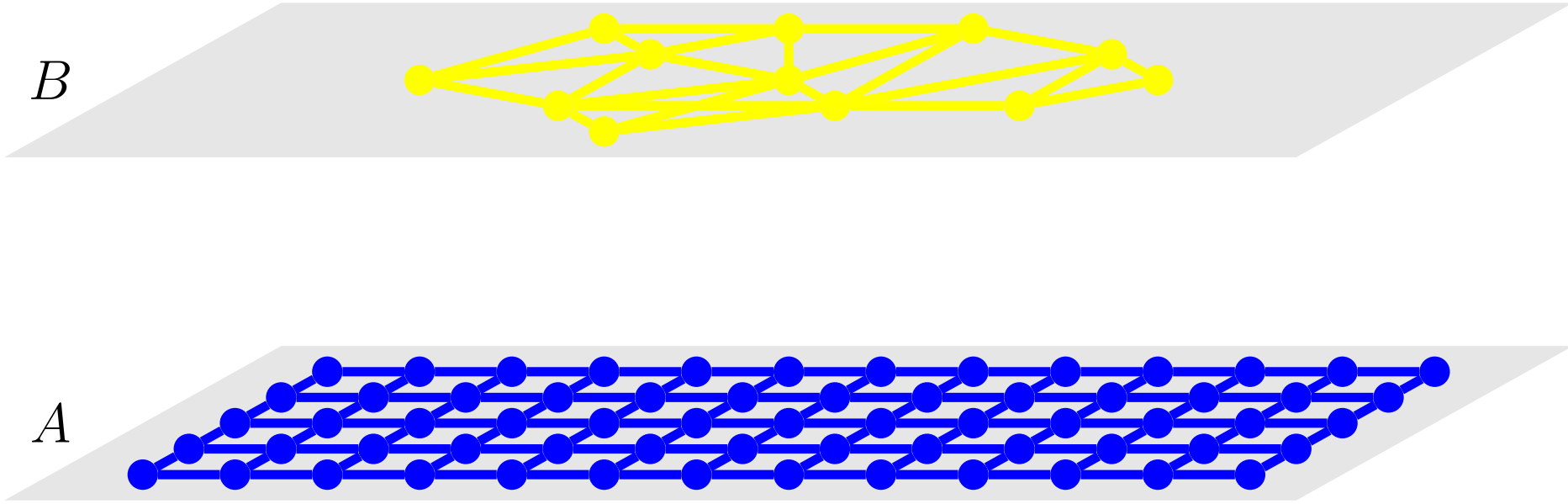
3. Segmentation $\Longleftrightarrow$ Recognition

   This is achieved in a graph partitioning framework where we simultaneously find the objects and their image supports.

Our Approach to Object Segmentation



Joint Pixel-Patch Grouping: Criterion

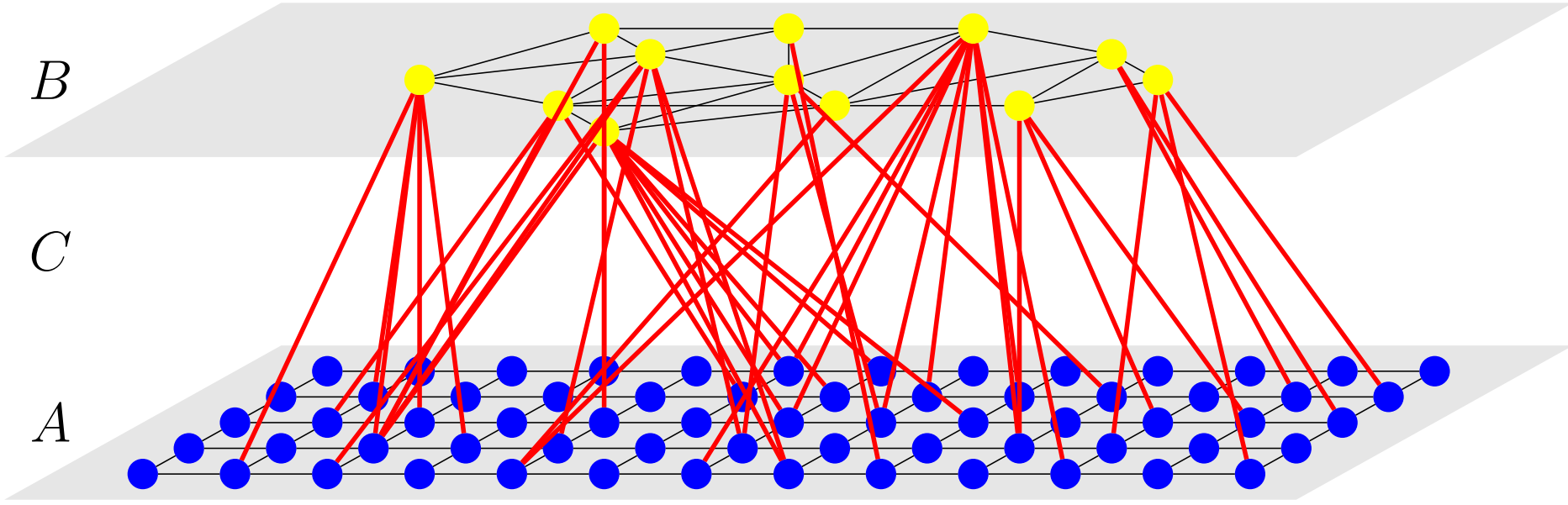


Pixel affinity A: based on intervening contours

Patch affinity B: based on spatial compatibility

Overall goodness: based on normalized cuts

Joint Pixel-Patch Grouping: Consistency



A joint partitioning has a feasible object segmentation interpretation only if: pixels for the patches in the same group also belong together in the corresponding pixel-group; and vice versa.

Integration Model

- Find the best organization among feasibles only.
- Constrained normalized cuts on the joint graph:

$$\text{maximize} \quad \varepsilon(Z) = \frac{1}{K} \sum_{l=1}^{K} \frac{Z_l^T W Z_l^T}{Z_l^T D_W Z_l}$$

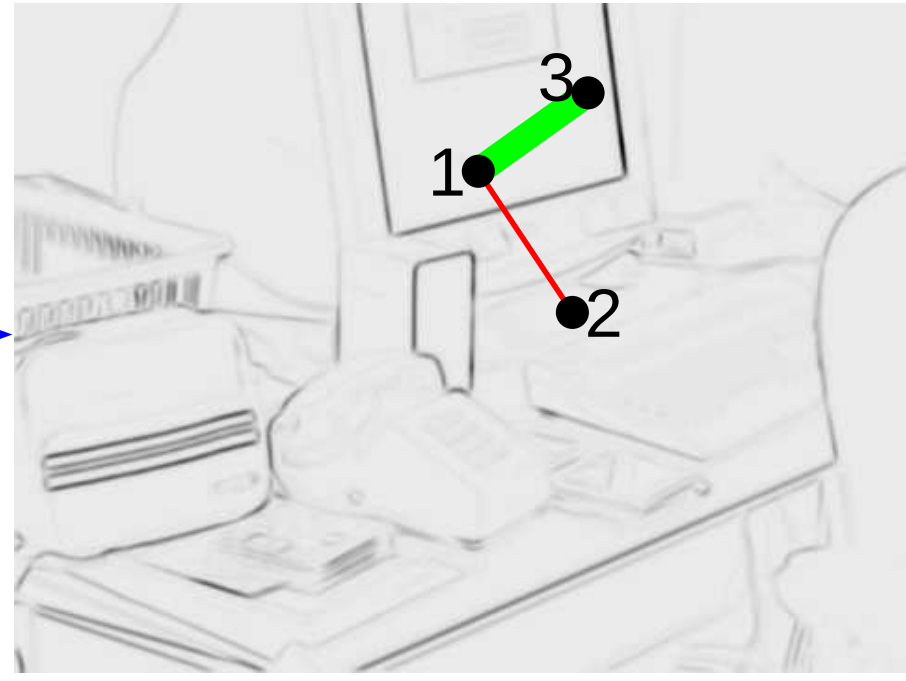
$$\text{subject to} \quad Y = CX$$

$$\text{where} \quad Z = \begin{bmatrix} X \\ Y \end{bmatrix}, \quad W = \begin{bmatrix} A & \\ & B \end{bmatrix}.$$

- Efficient eigen-based solution for near-global optima

(Yu & Shi: 2001)

Pixel Affinity based on Intervening Contours

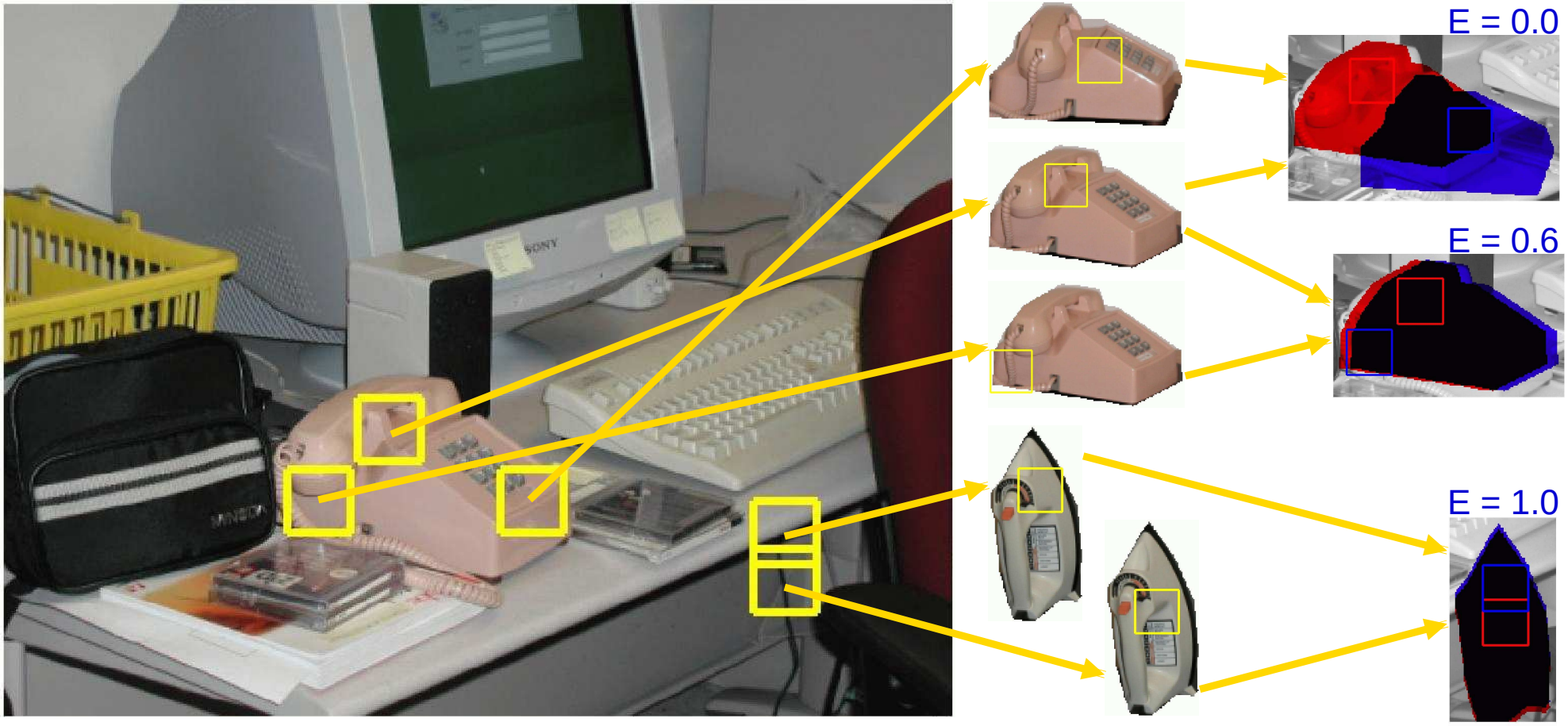


image

edge magnitudes

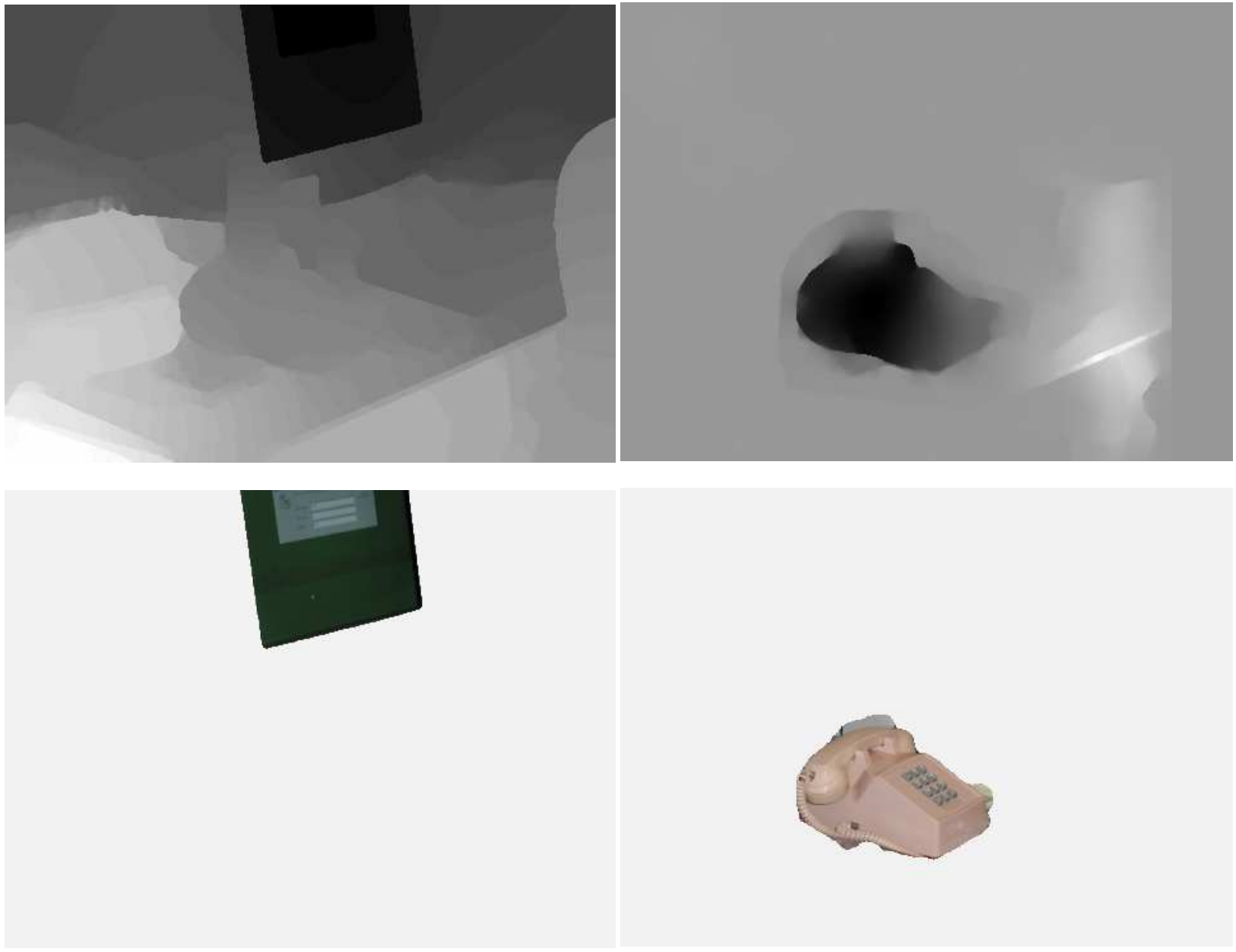
Pixels that are intersected by edges have low affinity.

Patch Affinity based on Spatial Compatibility

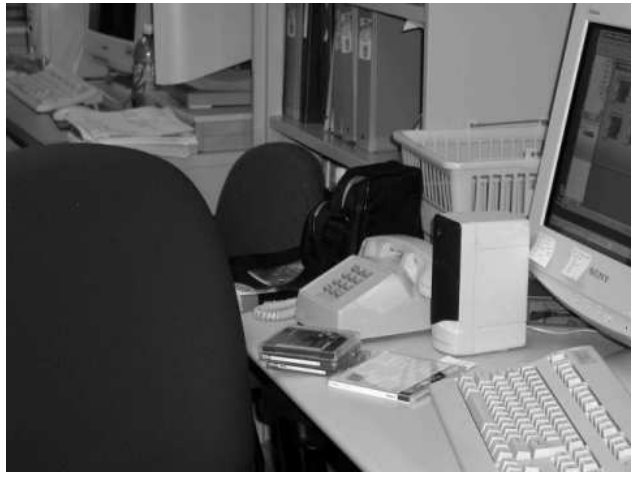
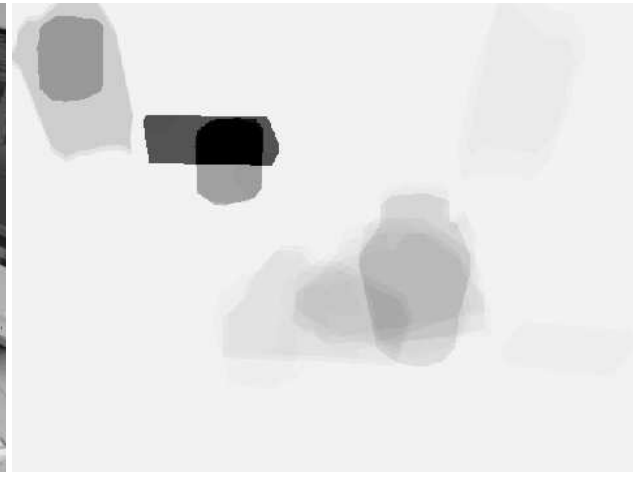


Patches with mis-aligned object silhouettes have low affinity.

How Object Knowledge Helps Segmentation



How Segmentation Helps Object Detection

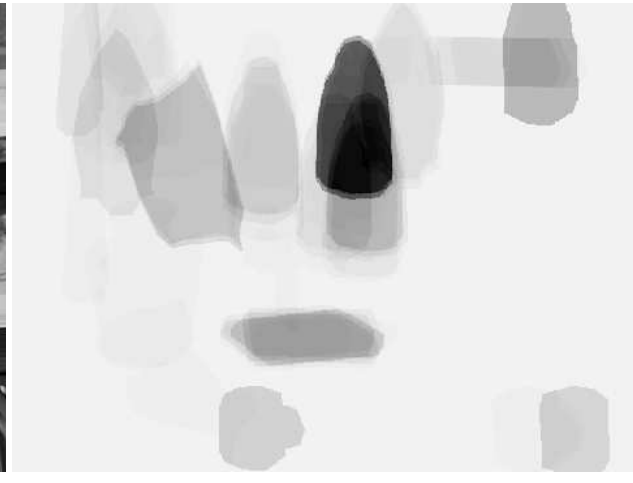
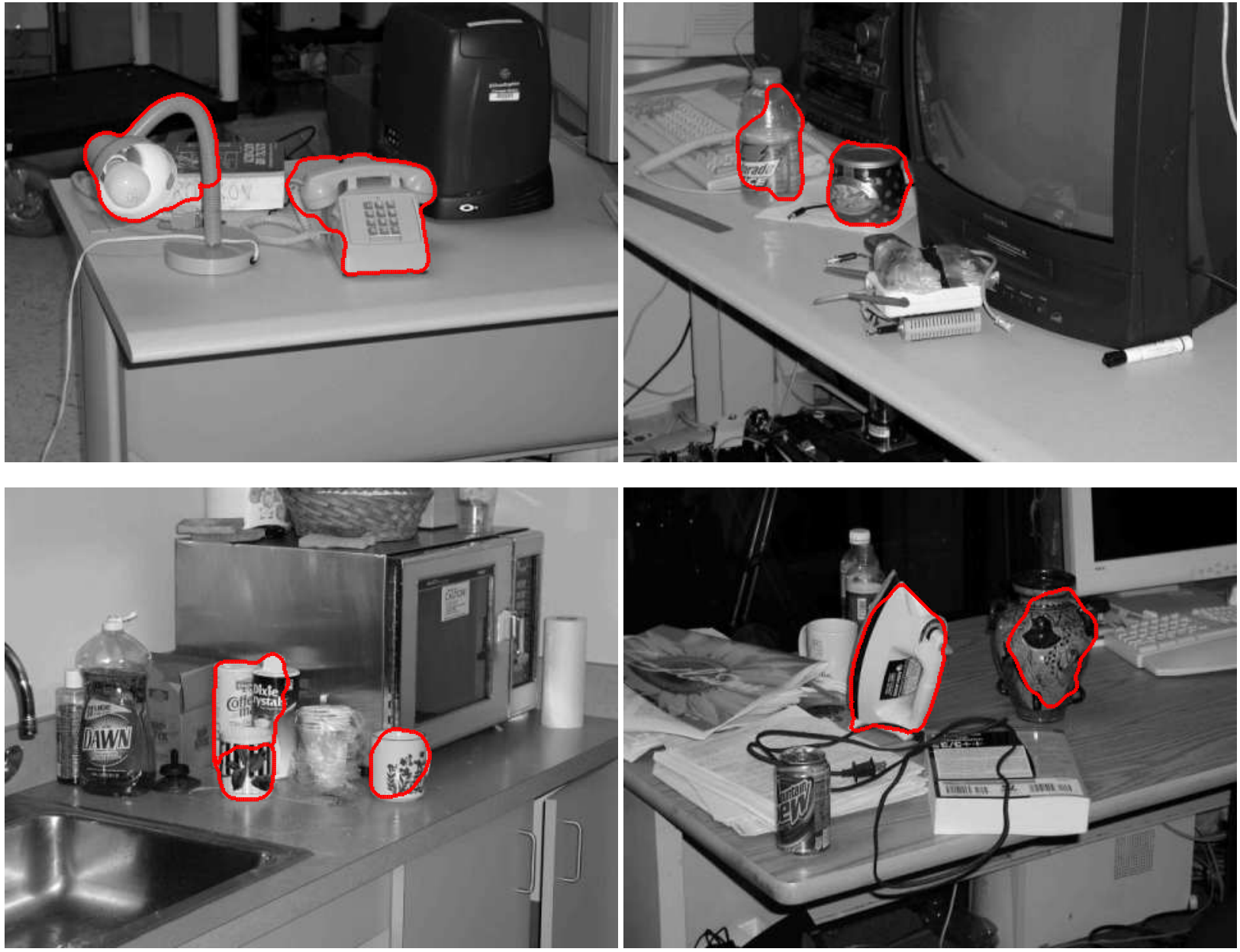
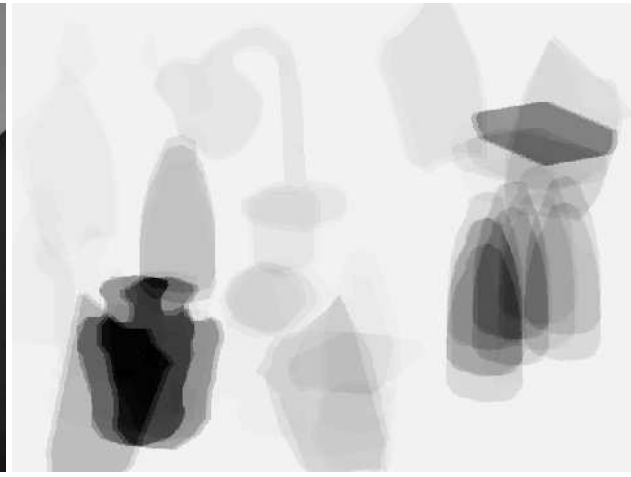
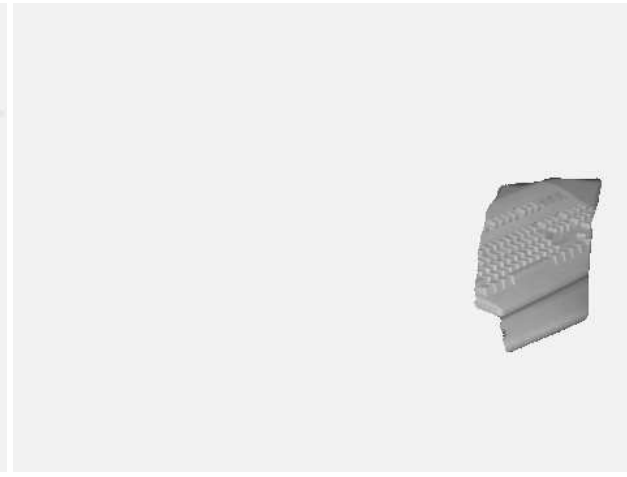




image | patch density | segmentation

Equally Applicable to Multiple Objects



When Does Our Method Fail

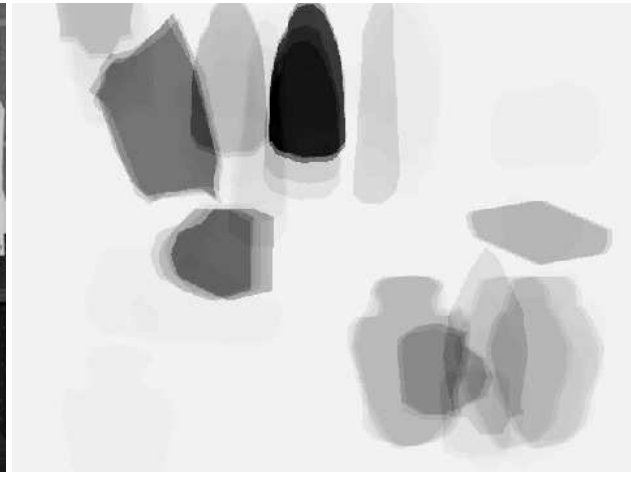
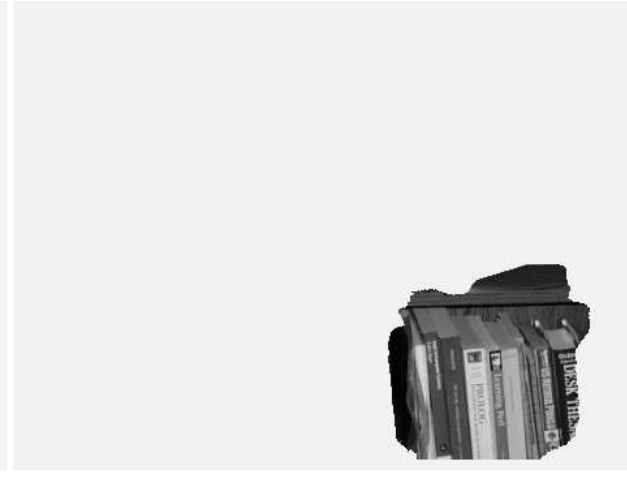




image patch density segmentation