SHADOW-FREE SEGMENTATION IN STILL IMAGES USING LOCAL DENSITY MEASURE

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DENSITY MAP MOTIVATION

Input

Textons [Malik et al 2001]

Grayscale

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Grayscale

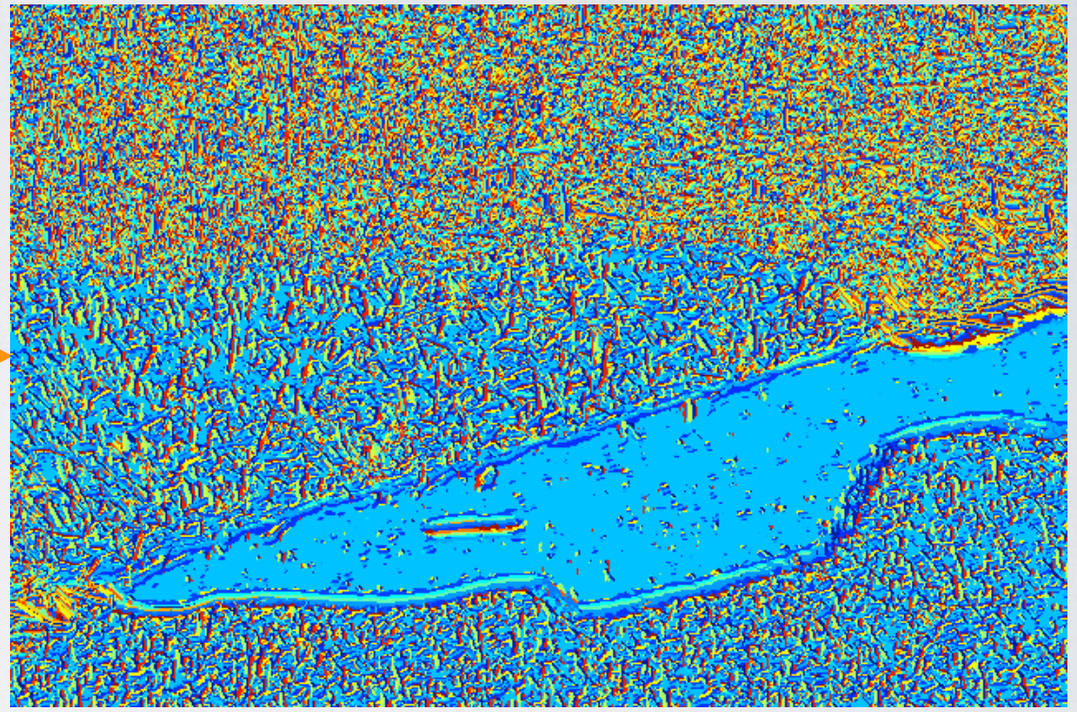


IMAGE DENSITY MAP

- Intuitively density measures how a function changes locally over multiple scales
- Define a measure function on the image over a radius

$$\mu(\mathbf{x}, r) = \sum_{\|\mathbf{y}-\mathbf{x}\| \leq r} I(\mathbf{y})$$

- Hypothesize that it varies as an exponential of the radius

$$\mu(\mathbf{x}, r) = k r^{d(\mathbf{x})}$$
$$\log(\mu(\mathbf{x}, r)) = \log k + d(\mathbf{x}) \log r$$

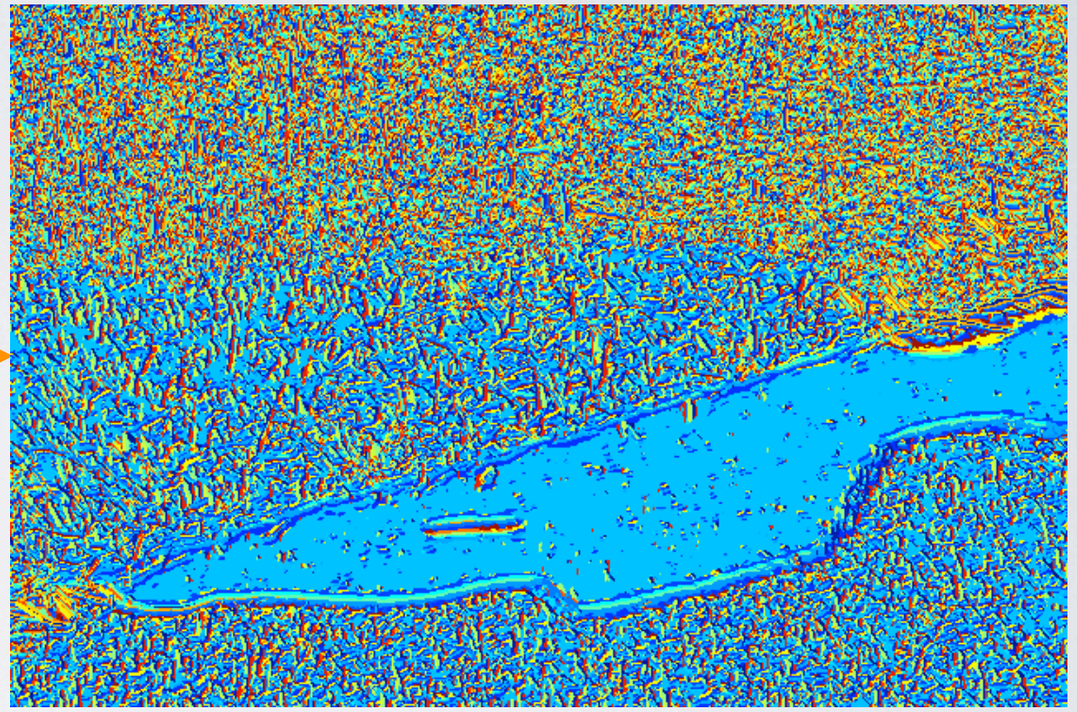
- $d(\mathbf{x})$ is the local density measure at pixel $\mathbf{x}$

APPLICATION TO TEXTURE DESCRIPTION

Input

Textons [Malik et al 2001]

Grayscale



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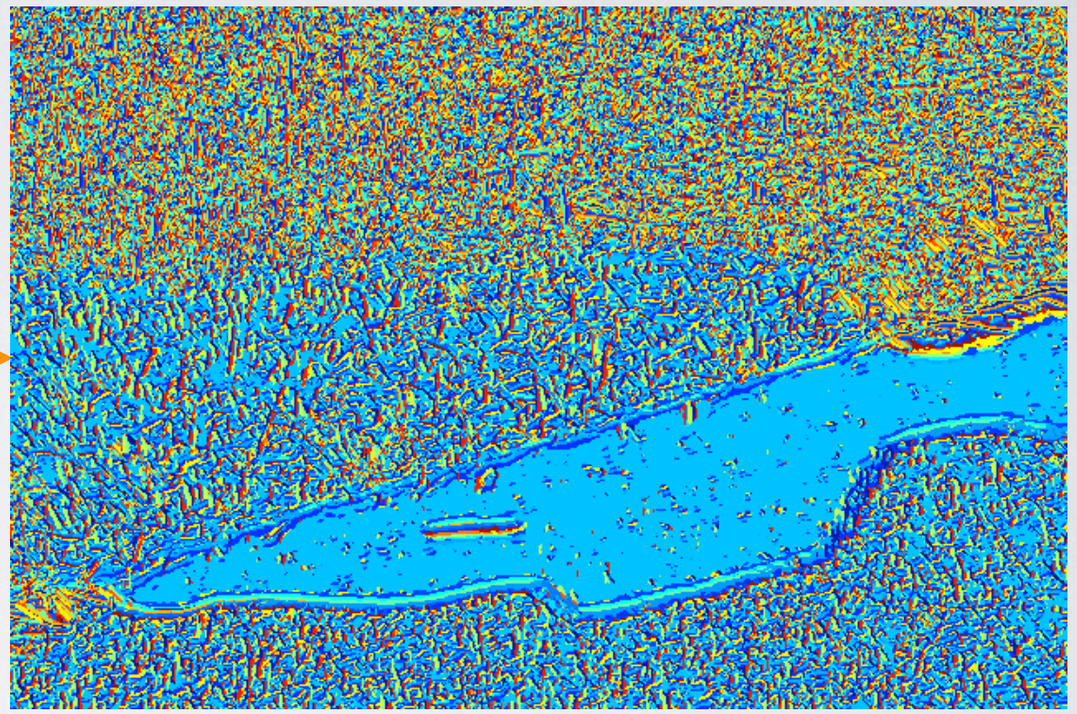
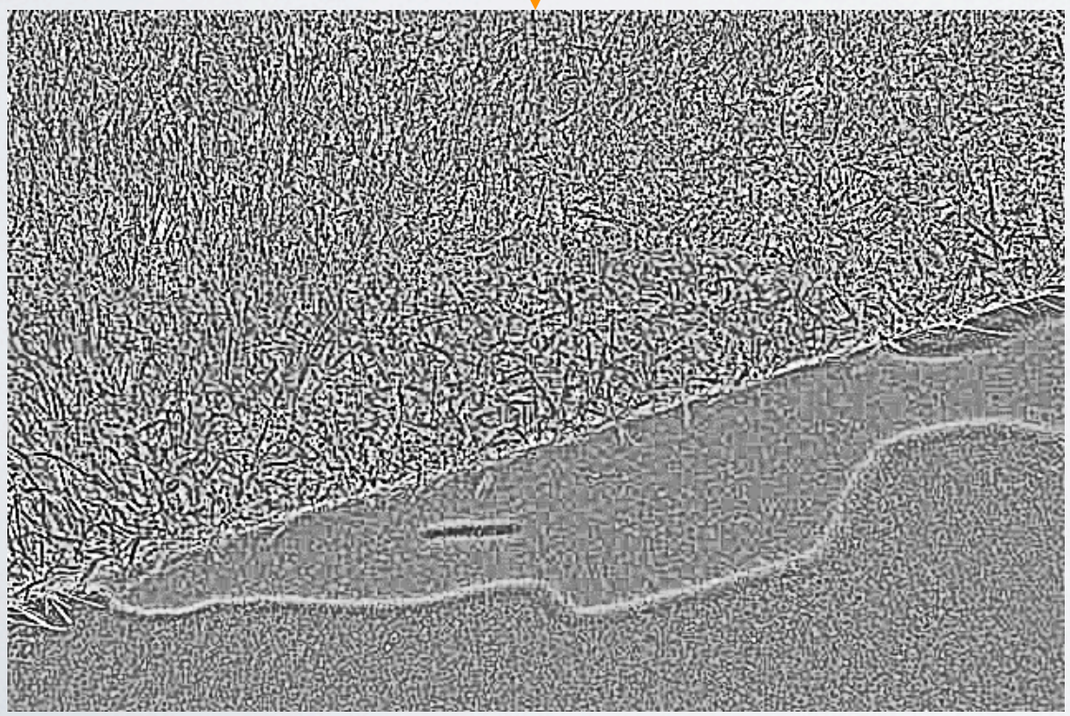


Density map



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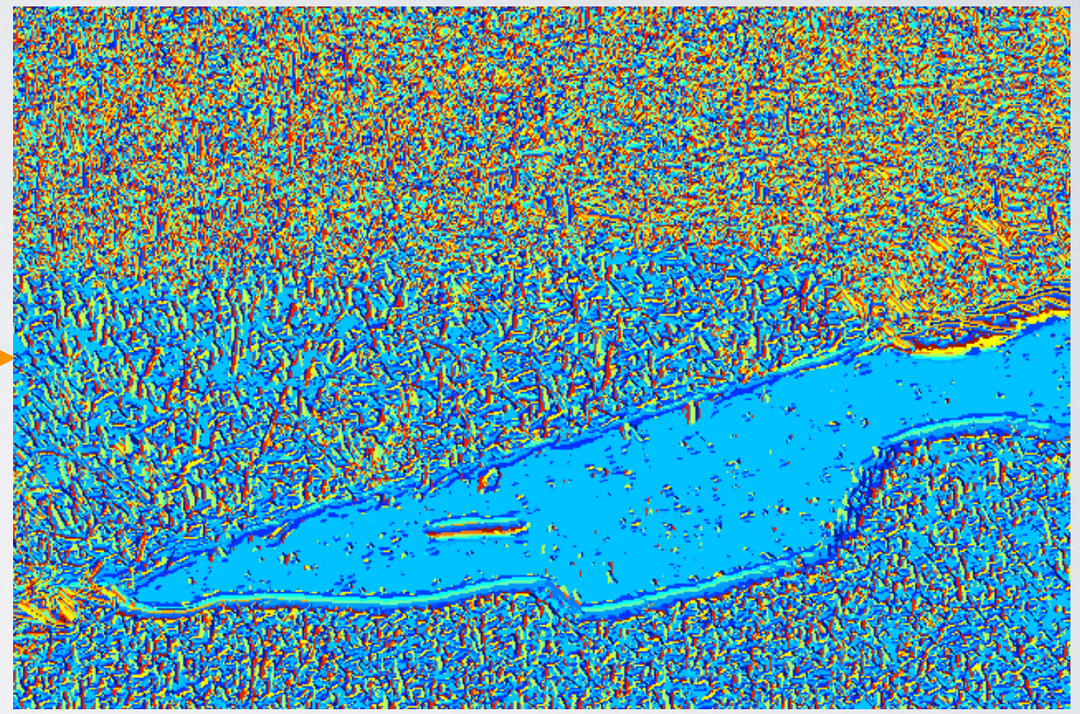
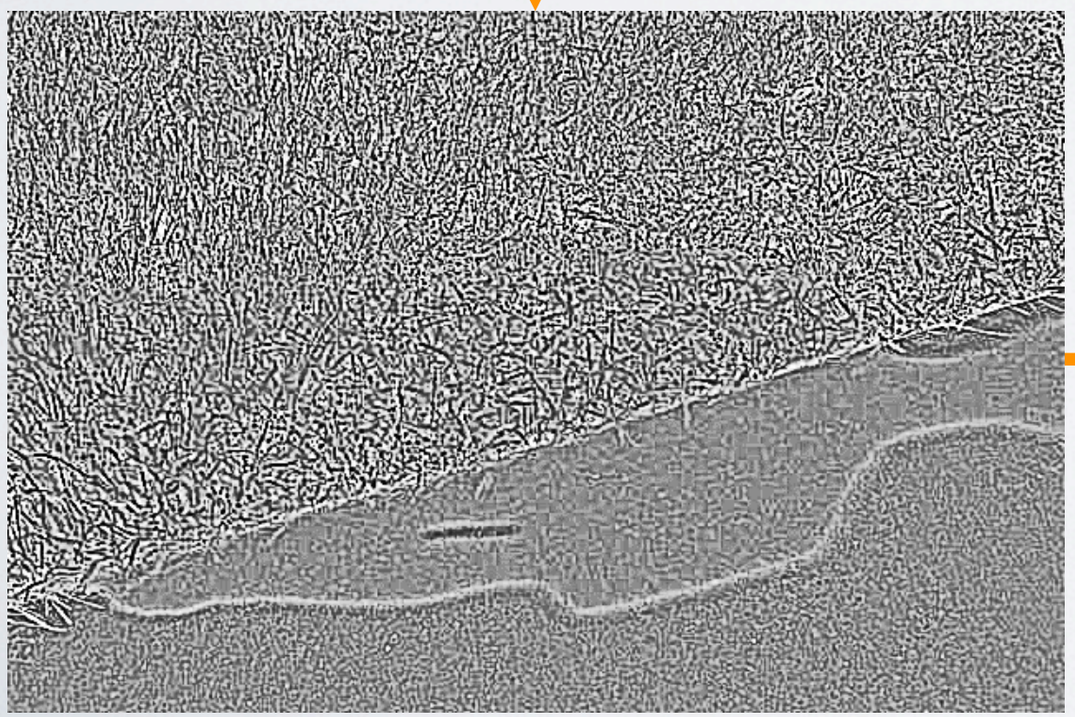
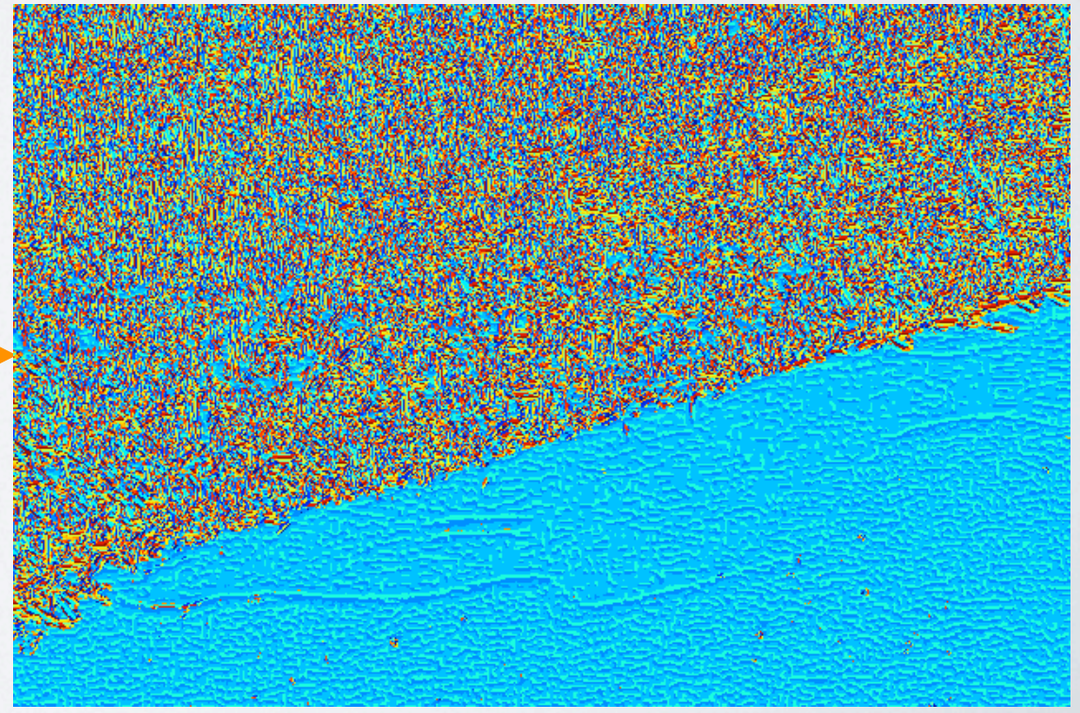


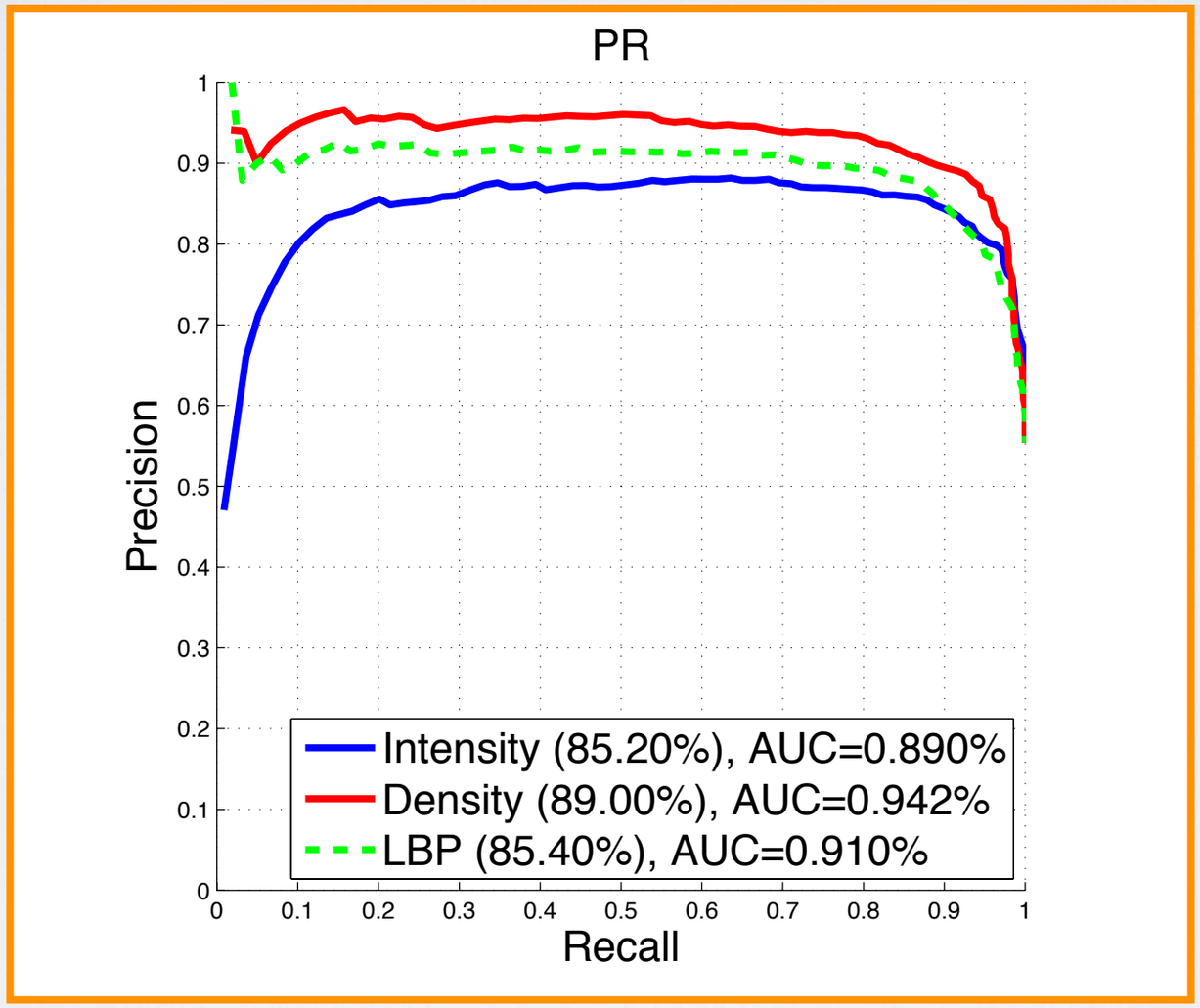
Density map





SHADOW BOUNDARY DETECTION

- Goal: given a boundary in an image recognize if it is a shadow boundary



intensity + texture

FIGURE GROUND SEGMENTATION AND SHADOWS

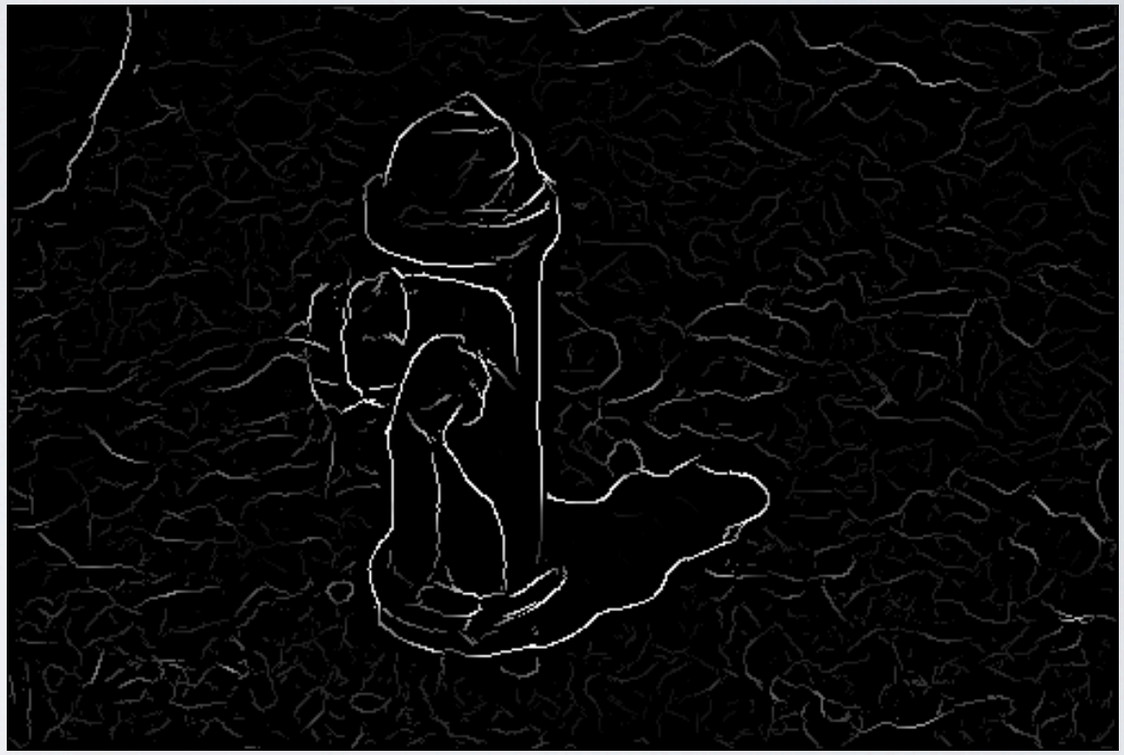
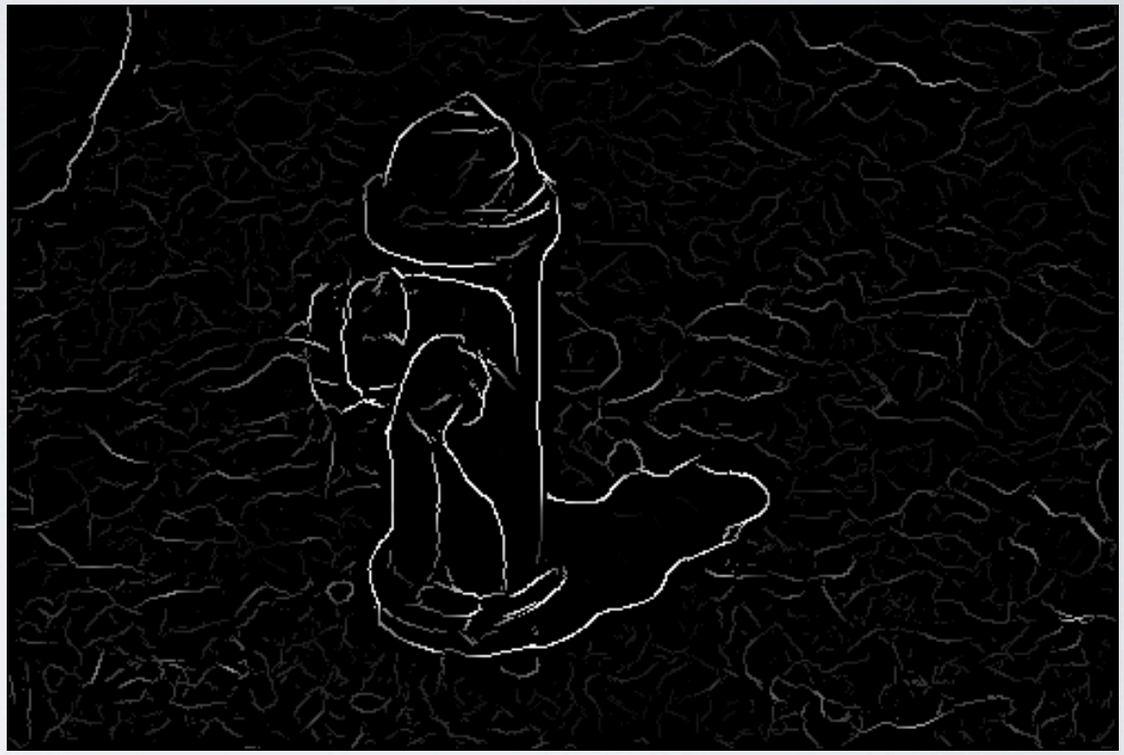


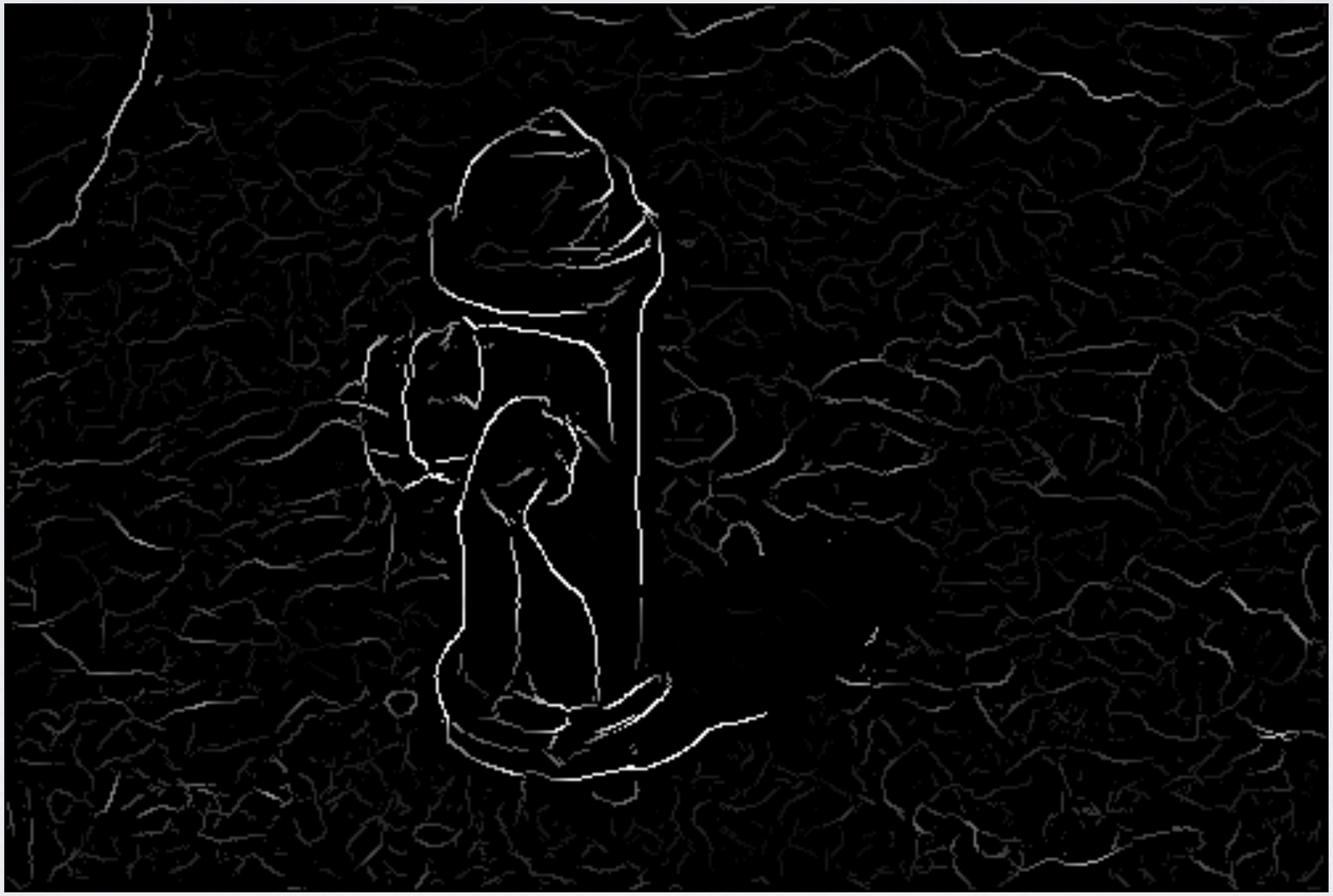
FIGURE GROUND SEGMENTATION AND SHADOWS



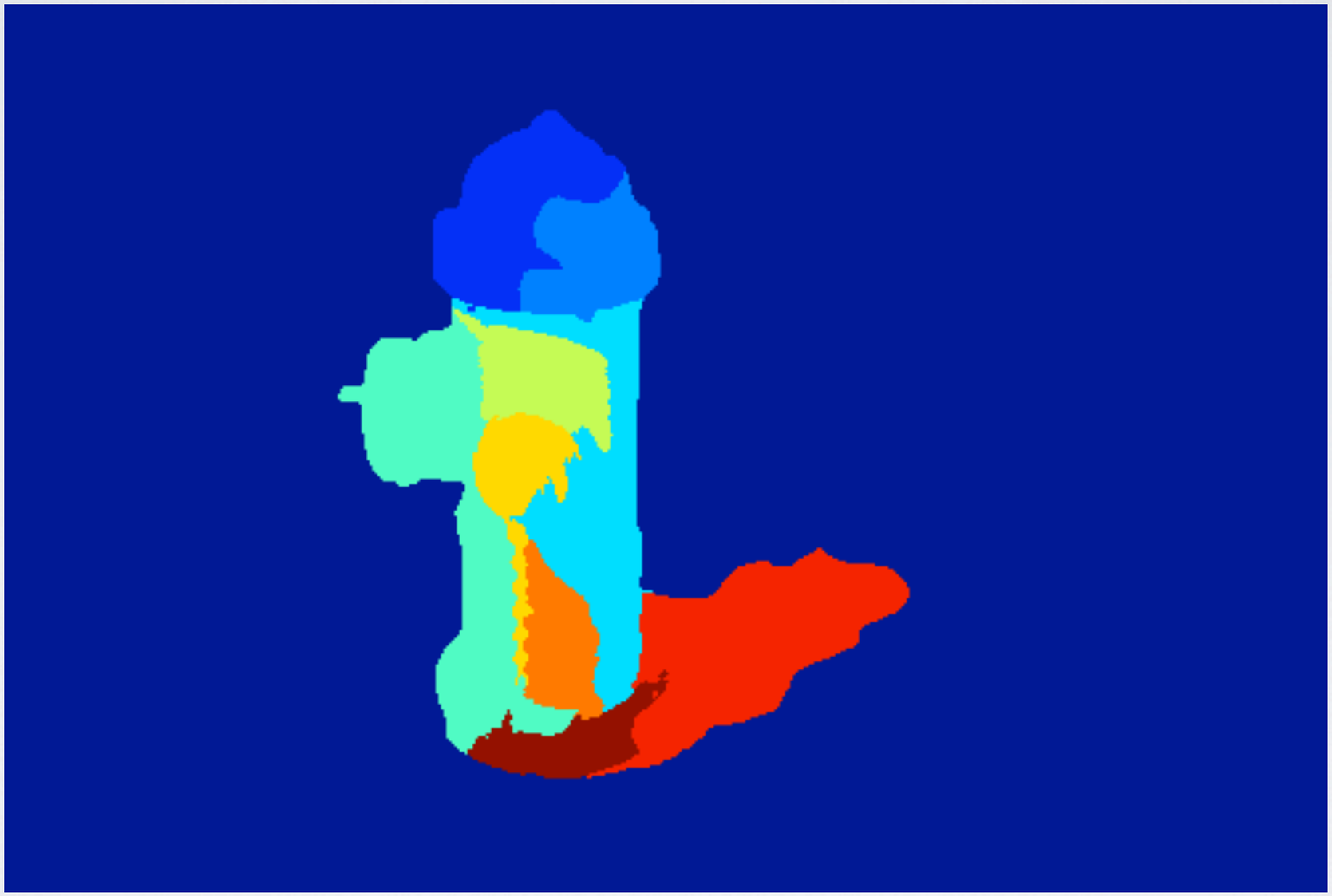
STEP 1: SEGMENT

STEP 2: DETECT SHADOWS

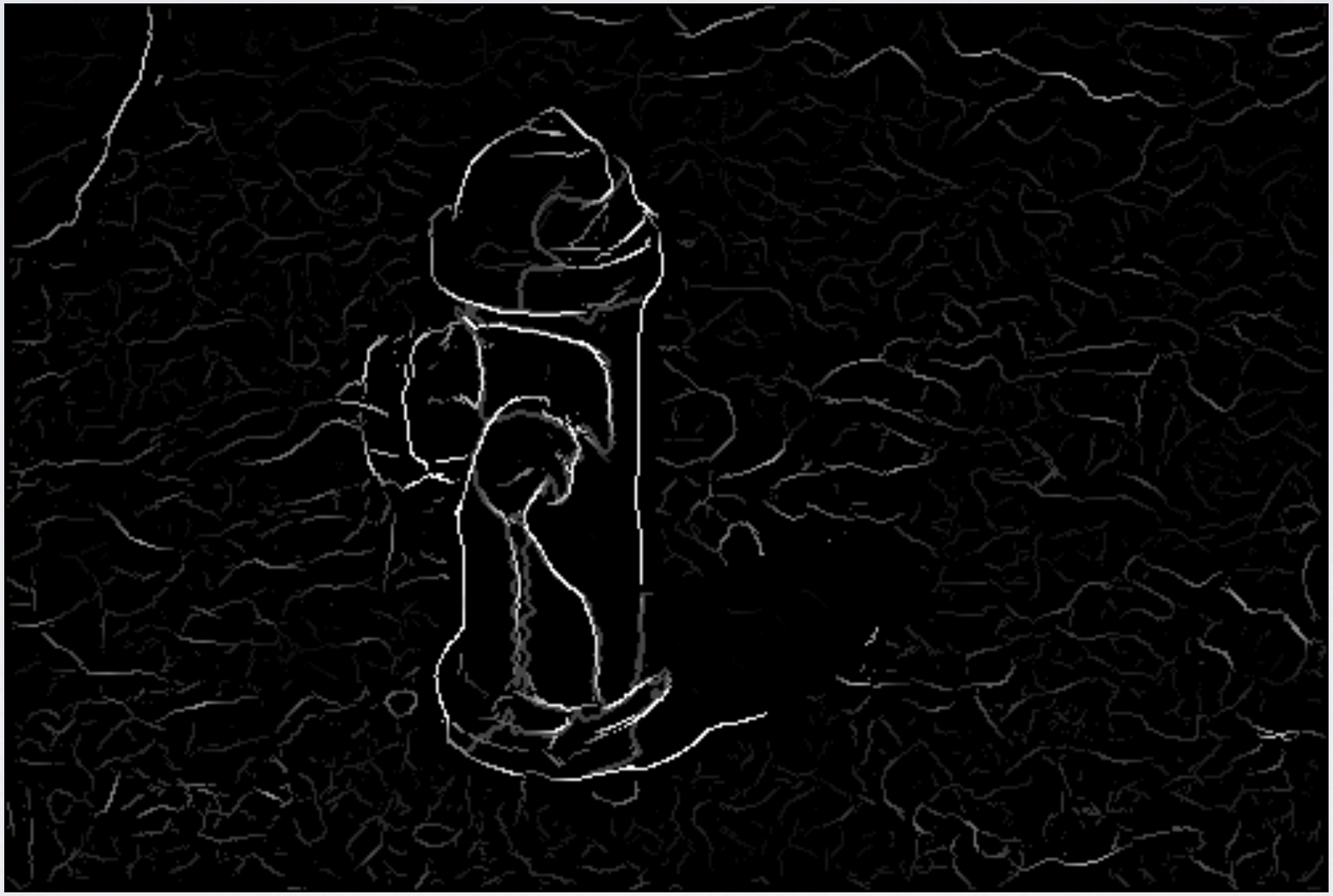
STEP 3: ATTENUATE STRONG SHADOW EDGES



STEP 4: OVERSEGMENT THE SEGMENTATION AREA



STEP 5: ADD EDGES BETWEEN SEGMENTS



STEP 6: SEGMENT AGAIN

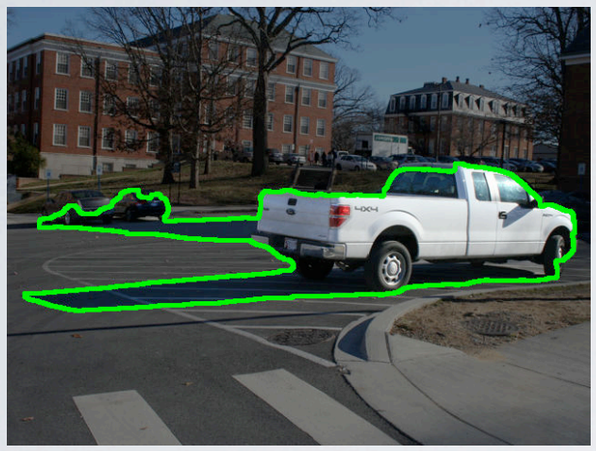
QUANTITATIVE EVALUATION

- Dataset of 53 outdoor images of objects affected by shadows
- Groundtruth segmentation and segmentation initialization for each image
- Compared 4 algorithms

Algorithm	F-measure
Baseline	0.77±0.027
Intensity textons	0.81±0.036
LBP	0.82±0.039
Density textons	**0.84±0.033**

EXAMPLES

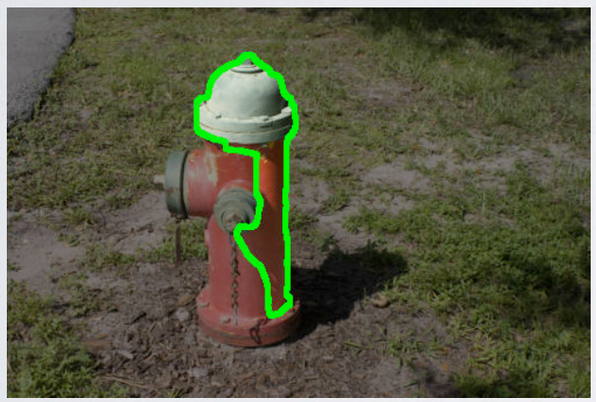
Baseline

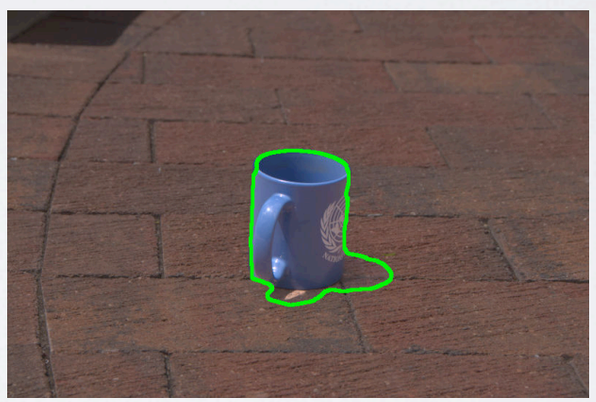


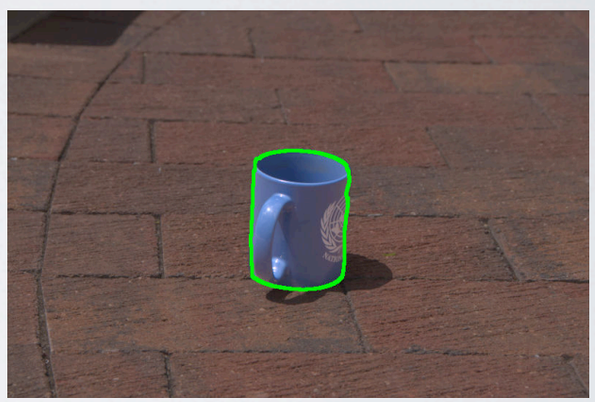
Shadow-free

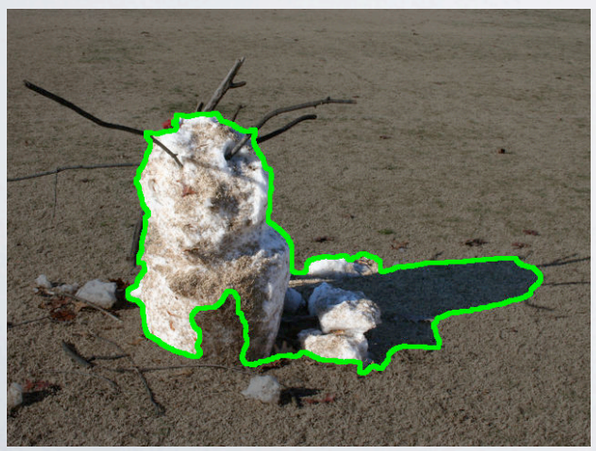
Baseline

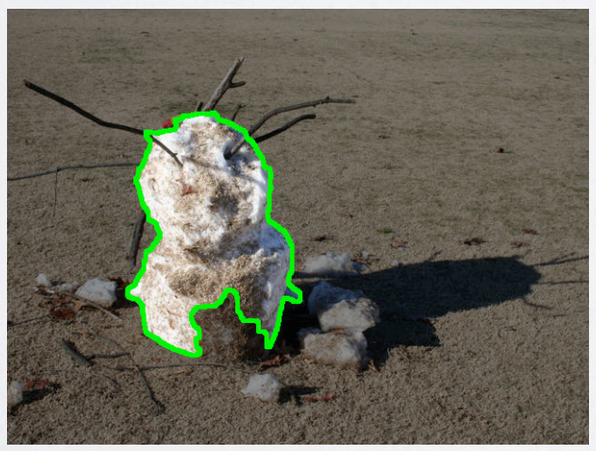
Shadow-free

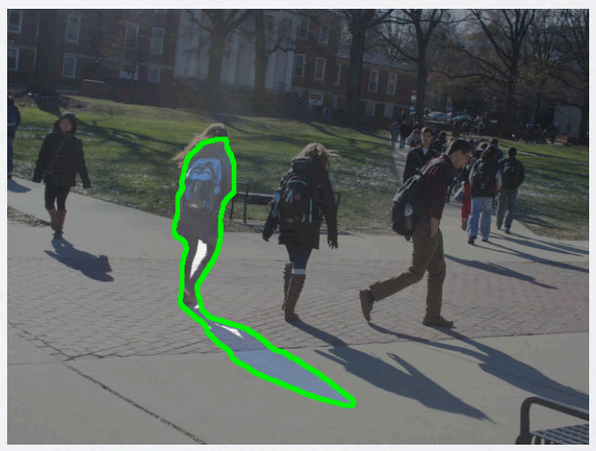


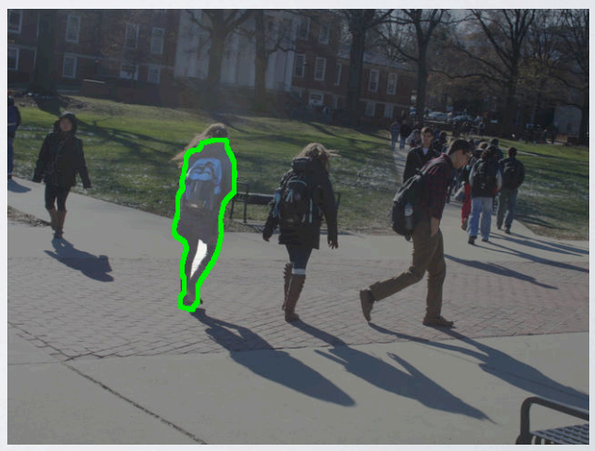












THANKS FOR YOUR ATTENTION

Questions?

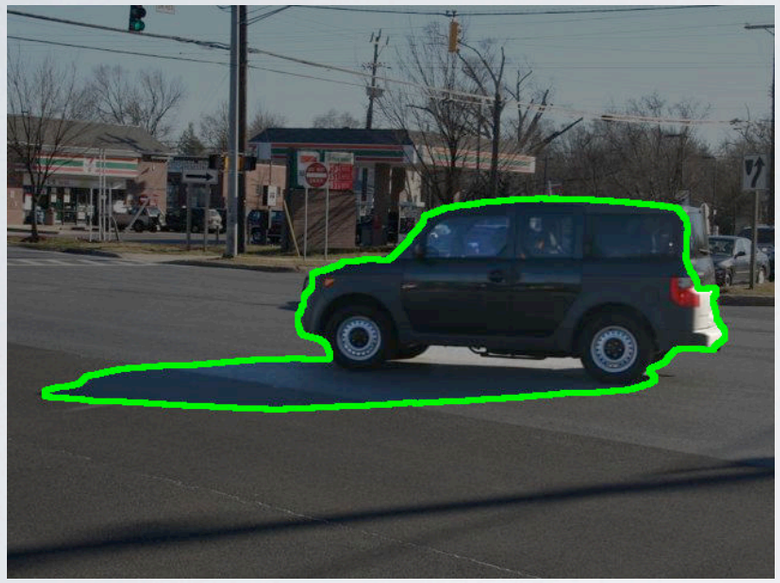
Code available online at www.umiacs.umd.edu/~aecins/

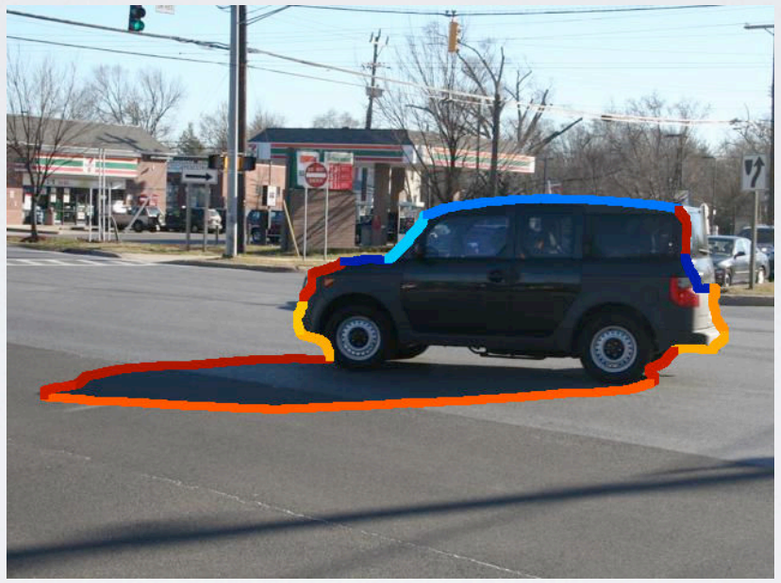
FAILURE EXAMPLES

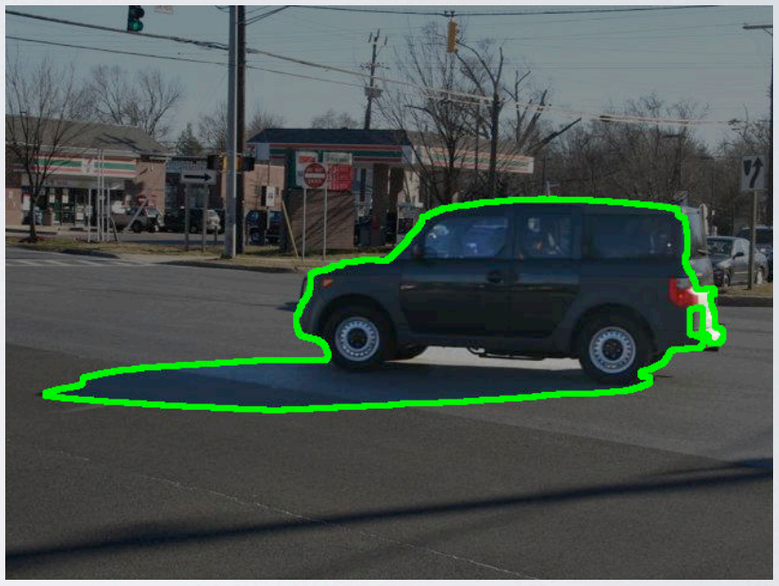
Baseline

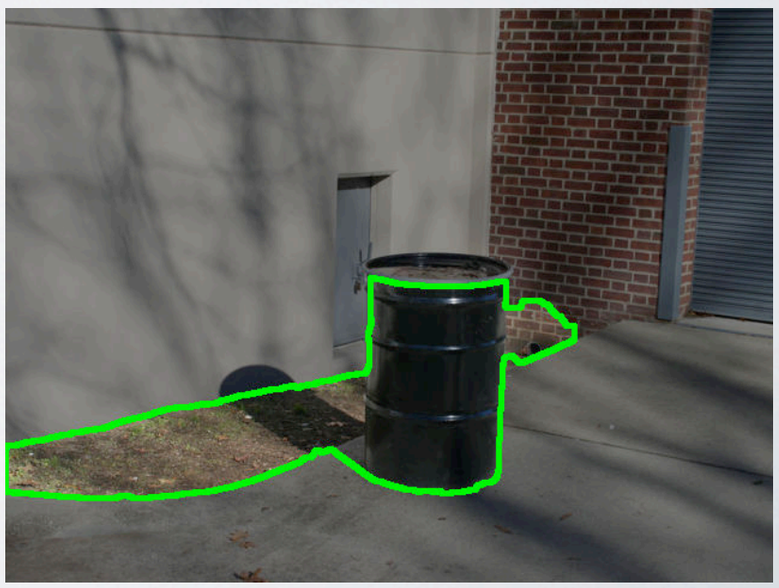
Shadow detection

Shadow-free









IMPORTANT PROPERTIES OF THE DENSITY MAP

Invariant to local multiplicative changes to intensity

$$\alpha\mu(\mathbf{x}, r) = \sum_{\|\mathbf{y}-\mathbf{x}\| \leq r} \alpha I(\mathbf{y})$$

$$\alpha\mu(\mathbf{x}, r) = \alpha k r^{d(\mathbf{x})}$$

Preserves textural features